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UNIVERSITY OF MICHIGAN
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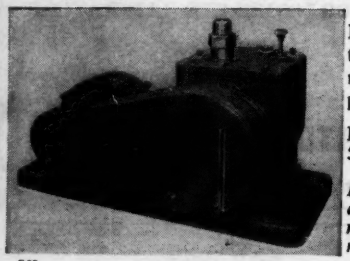

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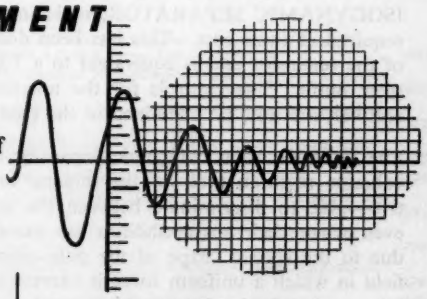

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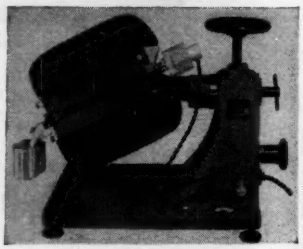

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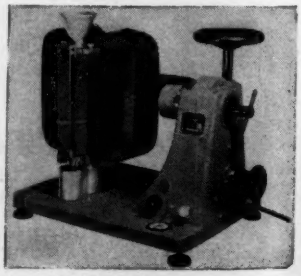

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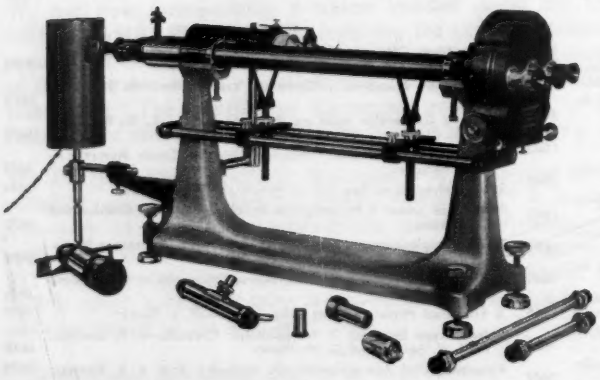

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THE DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

THE first report of the new Council for Scientific and Industrial Research* sets a fresh pattern in reporting on and discussing the work of the Department. Shorn of much of the detail which characterized recent annual reports of the Department—the work of the research associations forms the subject of a special report since issued, while the Council's Industrial Grants Committee is also surveying both the work of the associations as a whole and the methods used to assess and administer the Government grant—the annual reports are obviously intended to be limited to a review of some of the main problems of policy, such as the Advisory Council's later reports provided. Description of particular activities is left to the reports of the several research stations and boards.

This policy has obviously much to commend it, though three comments might be made. First, the problem of conveying to the public and to Parliament a clear and balanced picture of the work of the Department as a whole remains to be tackled. It cannot be done piecemeal, and while it remains undone the work is always liable to be in jeopardy, even with expenditure running at no more than £10,000,000 a year. Second, and not unrelated, some of the space saved could have been given to making the financial statement provide a self-contained comparison at least of year-by-year fluctuations. Third, there are activities of increasing importance on which information does not appear to be available, either in the Council's own report or in any sectional report; as example may be mentioned the work of the Intelligence Division, which is concerned in activities such as translating and scientific libraries that have been the subject of continual inquiry in Parliament, and the Department's work in the human sciences and economics. Even if the Human Sciences Committee which—following the dissolution in agreement with the Medical Research Council of the two joint advisory committees on human relations and on individual efficiency in industry—the new Council has set up publishes an annual report, it is still desirable that information as to the expenditure on these activities should be available to Parliament and to the public.

The Council begins its report with a review of the forty years of change since the tasks of the Department were set out in an Order in Council dated July 28, 1915. By 1955 the estimated public and private expenditure on research and development in Great Britain had risen to £300 million, of which 60 per cent was on defence, and more than twenty times as many graduates were engaged in scientific research and nearly forty times as many in technological research and development as there were before the First World War. More interesting, however, than the three groups of changes behind these figures which are noted in the report is the indication of the weight which the new Council appears to attach to social and economic research. It refers first to the value of systematic research on the social and economic causes and results of technical change; on the nature of industrial operations and their management; and on the reasons for high and low productivity. A reference to the improvement of abstracting services and technical publications and to the serious problems of technical communication follows, and finally comes the acknowledgment that co-operation in research must extend beyond the natural sciences, since the social and economic impact of technical change must influence the well-being of whole communities.

As has already been noted, no information is available in the present report on the Department's expenditure in this field. The new Council has reviewed the work which the Department has helped to sponsor in Britain since 1953 mainly with support, under the Conditional Aid Scheme, from counterpart funds derived from United States economic aid. It sees reason for continuing work in both fields; but, as regards industrial economics, it considers that the Department should for the time being concentrate on the application of economic criteria in framing its policy for scientific research and on such studies as are necessary for an adequate understanding of the economic implications of that work. A separate Economics Committee under Prof. E. A. C. Robinson has been formed with appropriate terms of reference.

There is a brief section on scientific and technical information in which the need is acknowledged for local yet comprehensive information centres for small and medium-sized companies, in order to ease the flow of technical information to industry and to handle specific technical inquiries; and the Council indicates also its intention of considering what part the Department should play in establishing a national network of information centres, supported at least in part by local funds. It also states its intention of reviewing Government grant policy in relation to research associations during the coming year in the light of the survey by the Industrial Grants Committee already in progress. In the meantime, during the past year, revised terms of grant have been offered to, and accepted by, fifteen research associations, and there is nothing in the present report to show whether or not any change in general policy there is yet contemplated.

The two main topics discussed in the present report are the general policy to be adopted towards the research stations of the Department, which, reasonably enough, are regarded as the Council's major financial responsibility, and that to be followed in relation to grants for postgraduate training and special researches. The Council has already begun to examine

* Department of Scientific and Industrial Research. Report of the Research Council for the year 1956–57. Pp. 69. (Cmnd. 428.) (London: H.M. Stationery Office, 1958.) 4s. net.

fully the present work and organization of the research stations in the light of its terms of reference, and has set up a Stations Committee under Dr. C. J. Smithells, the work of which is supplemented by *ad hoc* committees for selected stations. The relevant section of these terms of reference charges the Research Council with the organization, development and encouragement of scientific and industrial research and with the dissemination of its results; including the establishment or development of "institutions or departments of institutions for investigation and research relating to the advancement of trade and industry".

In considering the Department's role in the development of research, the Council suggests that it must ask what part it shall play in the conduct of pure research; what part its own stations should play in research of direct application to industry; how, given the growing need for expensive team-work, resources should be allocated to avoid spreading them over too wide a field; and to what extent industries served by the grant-aided research associations can be expected to shoulder the whole financial burden of an adequate research programme either now or in the near future. These and related questions are expected to occupy the Council for some time to come; but for the present, attention is concentrated on the first two. On the first, the Council believes that the universities are, and will continue to be, the main centres of pure research, but that the Department's own stations should also engage in pure research either in support of their own applied work or to supplement the work of universities whenever that seems to be necessary or desirable.

The implications of that view are best examined later in considering the Council's policy in relation to research and training grants, apart from noting the view that it is mainly a matter for the universities themselves and for the University Grants Committee that every care should be taken to ensure full use of the potential research capacity of university staff. The Council is not yet ready, however, to give a precise answer to the second question; although it is in serious doubt as to the adequacy of the resources at its disposal for all the responsibilities. It already believes, in fact, that the nation's research effort must be increased, and is convinced that the Department is doing work of the utmost importance; although the Council may not yet be satisfied as to the best way in which these resources should be deployed, or clear as to all the implications of the changes it proposes to make.

It may well be true, as the Council suggests, that there is a growing field of activity in which the Government has a direct interest and a special responsibility, and in which, therefore, the research work is appropriate to national research establishments such as the Road Research Laboratory and the Water Pollution Research Laboratory. Nevertheless, the distinction is not always easy to draw in practice, apart altogether from the value of close contact between pure and applied research. Some of the value of the work of the National Physical Laboratory and the Chemical Research Laboratory could well arise out of the contacts which they should foster between academic and industrial research, and it should be a prime concern of the Council to foster such contacts in every way possible, not simply by its policy of research grants but also by movement of staff and improvement of communications.

Moreover, to take one of the three stations with which the present report deals, the work of the Forest Products Research Laboratory is concerned mainly with industrial rather than with Government needs; and the Council is on firm ground in requesting the Timber Development Association to take over responsibility from January 1, 1958, for specified sections of work hitherto carried out by the Laboratory. This will enable the Laboratory to devote more time to research that could lay the foundation of new developments, for the work of this station is not entirely devoid of academic importance, and it holds also a significant place in Colonial products research. Again, stressing the inter-relation of many problems of distribution and storage of foodstuffs with production, the Council has invited the Agricultural Research Council to consider taking over the Low Temperature Research Station and the Ditton Laboratory, and integrating the programmes of both with its own.

Such a step could lead to some economy of effort, but it scarcely contributes to solving the problem with which the Council is immediately concerned. It raises a much larger issue of the appropriateness of the whole national organization for dealing with research and the level at which supervision should be exercised, to which Sir Hugh Beaver, himself an ex-chairman of the Advisory Council, directed attention in a recent address. Much the same criticism might be made of the Council's proposals regarding the Fuel Research Station, where it is the intention to concentrate on projects clearly of national importance which are not being prosecuted elsewhere. Work on air pollution, for example, is to be transferred to the new station at Stevenage, to provide a full scientific service for the departments administering clean air legislation, and, at the request of the Minister of Power, work on the synthesis of oil and chemicals from carbon monoxide and hydrogen is also to be transferred; but the remaining work of the Fuel Research Station will be completed at Greenwich or discontinued.

It is less apparent, however, that the work on mineral processing also proposed for Stevenage, where a unit is to be established to develop methods of extraction which can be applied to complex deposits from overseas, might not have been fitted in elsewhere. Although the Advisory Council on Scientific Policy two years ago recommended the establishment of a central mineral-processing laboratory for long-term research and practical investigations, it would seem that the Council might well have entered into fuller consideration of the location and organization of Colonial research than is apparent. It is right that it should seek flexibility in the Department, but in the very versatility it contemplates for the new Fuel Research Station, there appears to be at least some danger that the diffusion it has sought to eliminate in

food investigation, for example, may be created elsewhere. Further, before the Council crystallizes any definite conception of the functions of the Department's own research stations and of the research associations, in relation to industry or to the universities, it is important that it should have much clearer ideas of the inherent advantages and disadvantages of Government research stations and of co-operative research associations than are apparent in this report. It is on the extent to which the fullest use is made of those advantages, and the care which is taken to establish the conditions for maximum efficiency, that the success of the Council's policy will largely depend.

Nor is this unrelated to the Council's policy in regard to postgraduate training and research grants. Although the research associations themselves have been making valuable contributions to technical and techological education which may well be of increasing importance, the Department's most important educational reponsibilities are in regard to its grants for postgraduate training and for special researches. The Advisory Council had already replaced the old Scientific Grants Committee by a Postgraduate Training Grants Committee, under Sir Eric Ashby, which now handles nearly all fresh awards from public funds to postgraduate students in science and technology, and a Research Grants Committee, but the two are not entirely unconnected; and it is well to note that the Council is keeping in close touch with the University Grants Committee and with the Advisory Council on Scientific Policy in making grants to universities, and to read that the Council believes that the Department's expenditure on this activity must rise considerably.

It is not always appreciated how invaluable to the universities themselves are the grants which the Department of Scientific and Industrial Research makes to enable investigators of acknowledged standing to initiate and develop research of timeliness and promise, to enter promising new or changing fields of research, or to take advantage of the development of new techniques, quite apart from the opportunity which the Research Grants Committee may have for promoting, for example, a reasonable balance between research in nuclear physics and research in other branches of science and technology. All this would be difficult to achieve if the grants to universities from public funds flowed in a single stream which was required to cover all university activities.

The Council is clearly taking the right view and should receive strong support against any pressure to curtail its research grants to universities. The Research Grants Committee considers that university staffs could usefully expand the research they are undertaking, and the Council has agreed with the Committee's recommendation that the Department should do more to meet the rapidly growing needs of the universities. Grants for special research are estimated to reach £500,000 in 1957–58, and in the academic year 1956–57 the Committee has already considered 151 applications for grants, compared with 50 in the previous year, and recommended 115 awards, totalling £836,000, compared with 47 awards totalling £400,000 in the previous year.

Of new grants for special researches authorized during the session October 1, 1956–September 30, 1957, grants totalling £188,000 were for nuclear physics, and further grants for that purpose totalling £1,311,716 authorized in previous sessions were also in progress, apart from £360,000 for radio-astronomy at the University of Manchester. Some of these grants, it should be noted, are for periods of up to ten years; but when the contribution to European nuclear research of nearly a million pounds is kept in mind, it is obvious that there is need for some means of establishing a reasonable balance in research as well as of securing continuity. A panel of the Nuclear Physics Sub-Committee has already been appointed to advise on co-operation between British universities and the European Organization for Nuclear Research, and the Council is clearly alive to the many problems involved and is unlikely to encourage any lopsidedness.

What is more doubtful is whether, in fact, the Council possesses the requisite authority, and whether the whole research structure of Britain is suitable for the needs of to-day. Without entering here on these larger questions, it may be emphasized that if the new Council is to discharge successfully the tasks to which it is addressing itself, and particularly if it is to establish the conditions in the research establishments under its control which will attract workers of the highest quality and enable them to work most effectively, it will require the firm support of a public opinion alive to what is involved. Scientists have their own part to play in creating that opinion, but the new Council could well consider at an early date whether changes in its publications and publicity could not contribute most effectively to that end, and remove what has clearly been over recent decades a dangerous blind spot in central government at the highest level, irrespective of political party.

ATOMIC THEORY

Handbuch der Physik

Herausgegeben von S. Flügge. Band 35: Atome I. Pp. v+454. 99.50 D.M. Band 36: Atome II. Pp. vi+424. 88 D.M. (Berlin: Springer-Verlag, 1957 and 1956.)

ATOMS, or rather their electronic clouds, were the principal object of fundamental research in physics thirty years ago. Atoms were regarded as the key to micro-physics in general and to the understanding of molecules, nuclei and the solid state. The way in which atomic physics is treated in Geiger and Scheel's "Handbuch der Physik" shows clearly the great importance which was attached to that subject about 1930.

Now the novelty of atomic physics has worn off and its significance for current research is accordingly diminished. New discoveries are scarce. There are, however, a wealth of older results which are to be kept on record. These changes are taken into account in the new edition of the "Handbuch". Atomic physics is confined to two somewhat slender volumes,

including articles on atomic structure and atomic dynamics but avoiding digressions into other fields.

The general theory of atomic structure is presented in an article by F. Hund entitled "The Quantum Mechanics of Atoms" (Vol. 36; in German). The author is known for his original contributions to this subject. In the present article he exposes the relevant physical ideas with great care and without too much emphasis on mathematical techniques. The explicit use of group theory is avoided and symmetry is discussed in terms of familiar mathematics. Particular points in the premises, deductions and results of the theory are, when the author thinks it fit, explained and analysed in length. The merits of the author's approach are obvious; the article is within the grasp of non-specialists. It might, however, be argued that experts would have been better served by a compact and exhaustive record of the subject.

The general theory of atomic structure is expanded in two further articles which apply to atoms with either a very small or a very large number of electrons.

The hydrogen and helium atoms are the only cases where the accuracy of the theory matches that of the spectroscopic measurements. The theory of these atoms is set out in an article by H. A. Bethe and E. E. Salpeter entitled "Quantum Theory of One- and Two-electron Systems" (Vol. 35; in English), which has the form of a treatise where deductions are given in full, leaving no gap in the argument or any other ambiguity. The theory of the hydrogen atom is given successively in the non-relativistic formulation, in terms of Dirac's equation and, finally, taking account of radiative corrections, including the Lamb-shift. A brief account of the spectrum of positronium is added. The theory of the helium atom is preceded by a critical survey of the available methods of computation, and is presented in terms of the non-relativistic formulation and of the existing approximate relativistic two-electron wave equations. The treatment includes the interaction of radiation with hydrogen or helium atoms. The authors' method of presenting the subject is lucid, makes for good reading and results in a standard work of reference.

An approximative theory of heavy atoms which has gained some importance is reviewed by P. Gombàs under the heading "The Statistical Theory of Atoms" (Vol. 36; in German). The electron cloud has much in common with an ideal electron gas at low temperatures. Following from this analogy, semi-classical arguments are used for deriving the properties of electrons in atoms. It appears that the necessary mathematics is relatively simple. Although this procedure is somewhat arbitrary, results agree favourably with experiment. The literature on this method of approximation is extensive but a comprehensive review article was lacking; it is now available and should be received with interest.

A wide field of atomic dynamics, involving experimental results and theory, is surveyed in two contributions by H. S. W. Massey. Their subjects are "The Theory of Atomic Collisions" and "Excitation and Ionization of Atoms by Electronic Impact" (Vol. 36; in English). Since the author is known as a foremost expert in these subjects it is not necessary to enlarge on the high standard of his articles.

Progress in atomic physics during the past decades is very clearly shown in an article on the fundamental constants of atomic physics by E. R. Cohen and J. W. du Mond (Vol. 35; in English). Starting with a historical review it is shown that by 1930 the accepted (four-digit) values of atomic constants revealed discrepancies when different methods of determination were checked against each other. By 1941 these discrepancies had been resolved and the accuracy of the constants was increased to five digits. The main part of the article is concerned with modern experimental methods, mainly micro-wave spectroscopy, as applied to the determination of the fundamental constants. Whereas the results of measurement are not as directly connected with the desired results as was the case with older methods, this drawback is compensated by higher accuracy. In addition, statistical procedures are systematically employed in order to increase the accuracy in evaluating a given set of measured data. Thus, by 1955, the accepted values of the fundamental constants have become figures of six digits. The article shows that atomic physics is by no means a matter of the past.

In this list of contributions, subjects are missing which would ordinarily be regarded as parts of atomic physics. In particular, quantum theory in general, interatomic forces and experimental spectroscopy are not represented. These topics are, at least in parts, to be found in different volumes of the "Handbuch der Physik". So far as Vols. 35 and 36 are concerned it may be said that the contributions of the 'Handbook' to atomic physics are satisfactory.

R. Eisenschitz

ELECTRON MICROSCOPY

Electron Microscopy

Proceedings of the Stockholm Conference, September 1956. Edited by F. S. Sjöstrand and J. Rhodin. Pp. xi+355. (Stockholm: Almqvist and Wiksell; New York: Academic Press, Inc., 1957.) 85 Sw. kr.

THE 370 participants at the Stockholm Conference on Electron Microscopy, 1956, included ninety-nine from West Germany, seventy-eight from Sweden, forty from Great Britain, seventeen from the United States and smaller numbers from twenty-three other countries. Of the 138 communications recorded in these Proceedings, ninety-three are in English, forty in German and the remainder in French.

About one-fifth of them deal primarily with the development of the electron microscope or of the technique of using it. The remainder, although they involve electron microscopy, and in many instances include useful descriptions of specimen preparation, are essentially biology, to the extent of nearly four-fifths of the total; metallography, mineralogy and allied subjects; and structure of paper and textiles.

The remarkable progress in application of electron microscopy to the study of biological material is shown in the reproduction of many excellent micrographs, some, particularly of muscle and retinal receptors, at a magnification of more than 45,000, including one of muscle at 360,000, with no trace of excessive enlargement.

Although great improvement in embedding and microtomy, which has made these striking results possible, has naturally found its widest and earliest application in biology, it seems likely to prove of increasing usefulness in other spheres.

Somewhat surprisingly, electron diffraction forms part of the subject of only five communications.

It is clear from the description of apparatus used that the conventional electromagnetic microscope

continues to be by far the most popular. A British instrument of this type, of high resolving power, is an item of the new apparatus of which brief descriptions are given.

Included in the publication is an interesting brief summary of the proceedings of a symposium on X-ray microscopy and microradiography held at Cambridge in August 1956.

The editors appear to have achieved their object of having this record of the Stockholm Conference in print in the shortest possible time and keeping its size within reasonable limits. It is attractively produced and has the unusual merit of having the reproductions of micrographs, which are of a very high standard, in the most appropriate place, with the text to which they relate.

The Proceedings are a fitting tribute to Bodo von Borries, pioneer of electron microscopy, to whose memory they are dedicated.

H. I. MATTHEWS

THE SOIL AND THE GROWING PLANT

Soil–Plant Relationships

By Dr. C. A. Black. Pp. vii+332. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1957.) 56*s*. net.

IN no country in the world has so much attention been devoted to the scientific study of the soil as in the United States. The work did not begin as early as in England or Western Europe, and when it started the approach was different, the emphasis being on physical rather than chemical factors in view of the great importance of water supply and soil stability in American agriculture. Gradually the scope of the investigations widened and the subject is now very completely and adequately covered.

Dr. C. A. Black of the Iowa State College has rendered a valuable service in bringing together material scattered over a vast number of journals in many countries, and working out a connected account of the relations of the soil and the plant as at present understood. The book opens with a good description of the composition and structure of the soil and the building up of the mineral particles into crumbs which are surprisingly stable: their formation is attributed to inter-particle bonds; a conception which is more fruitful than the older view that the particles were simply stuck together by cementing materials such as ferric and aluminium oxides, organic matter, etc. Then follow accounts of the biotic conditions in the soil: the supply of water, air and nutrients, salinity and alkalinity. The effects of the major nutrients, nitrogen, phosphorus and potassium, on the plant and the modification resulting from various soil conditions are described at length: this group of sections occupies nearly half the book. Many busy soil workers will be grateful to Dr. Black for the wealth of material and the lucidity with which he has presented it.

The general layout of the book is similar to that of its chief predecessors, and does not suggest any great change in the structure of the subject in recent years. There has, however, been a vast accumulation of new facts. It would have been impossible to deal with them all in a book of this size, and the author has wisely preferred to give some details in the cases he selects, thereby making his account much more interesting than if he had tried to include or even to mention a larger number of papers. Some very good English work has suffered, however: there is no mention of H. G. Thornton's investigations on the relation of the nodule organism to its host plant, nor of the discovery by F. J. Richards and R. G. Coleman of the production of putrescine in barley when the supply of potassium falls too low, nor of E. M. Crowther's remarkable studies of the relationships between climatic and geological factors and the composition of soil clay and the distribution of soil types—although all these subjects are discussed.

Soil science covers so wide a field and trenches on so many subjects, especially when studied in relation to the growing plant, that investigators easily lose touch with each other, and in consequence it is practically free from controversy on any important scale. There are no wide-ranging fundamental hypotheses about which men can hold strong opinions and in great discussion open up new fields for study. While nothing can be done about that, one cannot help feeling that more use could be made of the empirical knowledge acquired by successful cultivators of the soil who have often discovered facts worthy of further study. The explanations offered may be unsound, but the observations are frequently well founded.

E. JOHN RUSSELL

THE SIGNIFICANCE OF BIOLOGY

Modern Science and the Nature of Life

By Dr. William S. Beck. Pp. xix+302. (London: Macmillan and Co., Ltd., 1958; New York: Harcourt, Brace and Company, 1957.) 15*s*. net; 5.75 dollars.

THE simplicity of this book is deceptive. From its unassuming manner it might be mistaken for a defence of science addressed to laymen, a defence of the cultural significance of science teaching addressed to the dons of other faculties, or an exposition of the philosophy of research for students. As any of these it would be excellent: but it is in fact a serious and philosophically literate presentation of the significance of biology in human thought, which could be read with profit at all levels of scientific achievement, perhaps with the greatest profit by the eminent and vocal. Readers may be warned of something out of the ordinary when they find a medical research worker as well grounded in 'fundamental' biology as is Dr. Beck.

His object is the defence of logical empiricism. He achieves it by a well-conceived exposition of the history of biological discovery, which he uses to provide illustrations of the logical processes which make for success or failure in experimental work. The biological emphasis is nicely calculated to re-assert the rights of biology in the educational system, against the political attraction of training magicians, gunsmiths and technologists, and the philosophical case is made with clarity and economy. Dr. Beck compares a biologist vowed to cancer research who proceeds by indiscriminate compilation, and who reaches retirement without, unfortunately, drawing any useful conclusion; his colleague, struck by the goal-seeking properties of organisms, who arrives at the logical need for a 'vital principle'; and a laboratory rat which profits by experience to form hypotheses, and then tests its hypotheses experimentally. Of these, only the third is employing the scientific method.

The book is full of equally pungent illustrations, and it profits by its own warnings. The only part of the argument which is seriously inadequate is the discussion of the reasons which lead scientists to differ in their approach to the same set of facts. Is the tendency to discover 'principles' and mistake them for explanations, or to prefer suggestive relationships to verifiable hypotheses, merely a matter of mental indiscipline? There is evidence that these predispositions represent personality types, not merely individual weaknesses. There is a systematic similarity in the kinds of error which individuals make: Dr. Beck mentions the grosser aberrations of scientific behaviour which affect performance—bad temper, fractiousness, and dishonesty—but does not discuss the fact that something which has been observed may be blocked completely from consciousness, for reasons of which the subject is quite unaware.

Nor does Dr. Beck deal with the possibility that there are problems which men do not want solved. These are the real source of the separation which he deplores between 'science', in which the self-discipline needed for the empirical method is admitted, and other fields of thought, where it is not. But his book is a valuable step towards a wider rationalism.

ALEX COMFORT

SCIENCE FOR CHILDREN

Seekers and Finders, Books 1–3

They dared to Ask Questions. Pp. viii+68. Magic, Science and Invention. Pp. viii+72. You Yourself: Fifty Straight Answers to Fifty Fair Questions. Pp. viii+64. By Amabel Williams-Ellis. (London and Glasgow: Blackie and Son, Ltd., 1958.) 6s. net each.

THE problem of introducing science to children has been brought out in a number of recent reports. In Britain in secondary modern schools little is attempted, while in primary schools almost nothing is done. Apart from the inadequacy of science teaching in our training colleges, which produces only a small number of competent science teachers, one of the great difficulties of interesting young children in science subjects is that there are few suitable books which could be used for class reading, apart from a limited number of books on natural history which are of outstanding merit.

In this series, Mrs. Williams-Ellis takes over the role of popularizer and does it most effectively. "They dared to Ask Questions" not only describes important stages in the lives of Pasteur, Darwin and Edison, but also shows how their investigations and researches led them to discoveries and ideas for which they have become rightly famous. Although there is no mention of 'scientific method' or inductive reasoning, there is also a chapter which illustrates these processes in a way which would command the admiration of most investigators. "You Yourself" answers fifty of the questions which are constantly being put to adults by exuberant children and, in doing so, conveys elemental knowledge in anatomy and physiology, as well as the way in which important principles have been unravelled. In "Magic, Science and Invention", Mrs. Williams-Ellis repeats the pattern of the first book with accounts of the lives of Linnæus, Marie Curie and the Wright brothers; she also uses the career of Dr. Thomas Beddoes to show that enthusiasm is not enough.

Each of these books is skilfully written with words which are carefully chosen to be meaningful to children. They are liberally and, sometimes, humorously illustrated and contain a number of suggestions designed to stimulate young readers to further thought and action. There is little doubt that they will be successful.

The real judges of this kind of book are children themselves. The first three have already been read by a number of children, who await other volumes in the series with eager anticipation. T. H. HAWKINS

AUSTRALIAN ACRIDOIDEA

The Grasshoppers and Locusts of Australia

By Dr. J. A. G. Rehn. Vol. 1. Families Tetrigidae and Eumastacidae. Pp. 326+21 plates. 1952. Vol. 2. Family Acrididae, Subfamily Pyrgomorphinae. Pp. 270+32 plates. 1953. Vol. 3. Family Acrididae, Subfamily Cyrtacanthacridinae, tribes Oxyini, Spathosternini and Praxibulini. Pp. 270+29 plates. 1957. (Melbourne: Commonwealth Scientific and Industrial Research Organization. Sold by Melbourne University Press.) A£2 each volume.

IN most arid countries with a rapid development of agriculture and grazing, many local grass-feeding insects, grasshoppers and locusts in particular, soon become important pests, requiring the attention of entomologists. Australia is no exception and the need for a thorough knowledge of local Acrididae was fully realized by the Commonwealth Scientific and Industrial Research Organization, which very properly decided that one of the essential steps would be a competent taxonomic revision of the local fauna, to enable economic entomologists to identify species of importance. The work has been entrusted to Dr. James A. G. Rehn, of the Philadelphia Academy of Sciences, and is being carried out in the United States with the material supplied by all museums in Australia.

As stated in the introduction to the first volume, "the general purpose of these studies is to supply readily usable keys", but the work is unsatisfactory in this respect. There is no explanation of the terminology used in keys and descriptions and, since the author tends to use many terms not accepted by other taxonomists, a reader may not be able to find their explanation elsewhere. Both keys and descriptions are written in a cumbersome and complicated style; for example, "Frontal costa with the lateral margins of inter-antennal section distinctly divergent ventrad about and enclosing a marked and relatively broad supra-ocellar frontal scutellum the profile of the lateral margins of which area is distinctly convex, and cut off from the more dorsal portions of the facial outline". Descriptions of genera and species are inordinately long, and this is due less to their completeness than to verbosity, which is bound to exasperate and to confound the user, who will find it difficult to distinguish characters of diagnostic value from the more trivial ones.

While the work fails as an aid to an economic entomologist, a taxonomist will find the author old-fashioned as regards the classification of the higher categories, since he either rejects or merely ignores some recently introduced changes in the system established in the last century by Stål, Brunner and others which he prefers to follow. Some of the author's attitudes to changes proposed by others are ventilated,

mostly in asides and footnotes. Those holding different views are accused of "dogmatic methods", "sweeping conclusions", "assertive bumptiousness" and other similar sins.

The Australian Acridoid fauna is still insufficiently known. Prior to the present work, 160 genera and 488 species have been described; in the three volumes now available 109 species are dealt with and forty-five of them are new. Judging from these figures, the total might reach some 800–900 species. The average number of pages per species is eight, due partly to the verbosity of descriptions, but also to the method of quoting under each species every specimen studied, with its location; the vast majority of the specimens are in the collections of the Division of Entomology Museum, Commonwealth Scientific and Industrial Research Organization, Canberra, and this designation is repeated in full, for example, on pp. 169–74 of Vol. 3, in the case of one common species, no less than seventy-three times. It is not surprising that the first three volumes comprise 866 pages of text; at this rate, the complete work should run to some 6,000 pages, or about twenty volumes. Although the price of a volume is reasonable, bearing in mind the excellent quality of the paper, careful printing and well-produced plates, both the size of the work and its total cost will scarcely make it suitable for the use of a practical entomologist even if he surmounts the difficulties inherent in the presentation of the material. Since the first three volumes have taken five years to publish, at least ten or fifteen more years would be required to complete the monograph, but when it is completed taxonomists will have cause to be grateful to the author for bringing together the available information on the Acridoid fauna of the Australian continent. Such shortcomings of the work as are mentioned above will matter less to specialists able to use it critically, than to economic entomologists. It is fortunate for the latter that some of the economically important genera of Australian Acrididae have in the meantime been revised (by Dr. K. H. L. Key) in a thoroughly critical and modern manner.

B. P. UVAROV

THINKING AS A SKILL

Thinking

An Experimental and Social Study. By Sir Frederic Bartlett. Pp. 203. (London: George Allen and Unwin, Ltd., 1958.) 18*s*. net.

"ONE thing, at least, about thinking is absolutely certain. All the various ways in which it is practised by human beings have become possible only as a result of prolonged processes of biological development." It is not that many people now doubt the fact of mental evolution proclaimed in this first sentence of the book under notice; but some will be surprised by the experimental programme he deduces from it. It is argued that, in the study of thinking, we must make use of clues available from the study of simpler but related behaviour. Thinking may be treated as a complex and high-level kind of skill, that is, as a kind of superlative of the skills that have received so much attention lately in the laboratory.

Whatever the cogency of the inference, and there will, perhaps, be those who will deny that it is valid, this is an interesting and novel approach to the problem of thinking. Particularly in the hands of Sir Frederic Bartlett, who was for a long time director of the Applied Psychology Research Unit at Cambridge, and is now consultant thereto, it is a promising one, since we owe a large part of what is known about skills to the work done under his guidance at the Cambridge laboratory. A skilled action, says Prof. Bartlett, must show the proper 'timing'; in order to achieve this, the skilled man must, among other things, anticipate what is to come while reacting to what is already present. There is thus, in the total situation to which he reacts, a gap he must fill. Most skills involve a series of activities separated by intervening halts, discrete movements—'processes' as Aristotle might have called them had he known the word—with survey periods in between. The physiologist will think here of the complex skill of reading, the eye of a quick reader coming to rest three to five times over a line of newsprint, and most of the total reading-time being spent during these fixations. These general characteristics should be found in thinking, the most highly developed skill of all.

In accordance with this programme the filling of the anticipatory gap is demonstrated in the experimental studies of verbal and other interpolation and extrapolation, including the difficult case where the situation-items may be disguised in one way or another. The anagram of the crossword puzzle is given as an example. The idea of 'gap-completion' was exploited in a series of experiments by Selz, during 1913–26, and the programme puts it into a new context. The survey-period and what happens there is examined in an interesting experiment on the reading of maps, where "new decisions are called for at predetermined stages"; the process of making decisions has been investigated in many other contexts and Bartlett has thrown what may be called a biological light on its meaning. These experiments show, consistently with the results of other workers, habit or stereotype overcoming evidence which should cause one to break the habit. Interestingly, in these map experiments people seem to choose the course of action offering the greatest number of apparent possibilities. Can we see here the adventurous Cambridge man living dangerously? The old problem of direction in thinking, worried at successively by Külpe, fifty years ago, and by the Gestalt psychologists, who indeed explained it by an extension of the gap principle, is given a new twist, perhaps as a sequel to the Cambridge elaboration of the airman's point of no return. Once activity, whether of movement or thinking, has reached a certain stage, the rest is predetermined, and there would seem to be little need of guidance towards the goal. The horse is, so to speak, on the home stretch. Something very like this was found in the experiments.

Perhaps the most exciting part of the book is contained in the last thirty-five pages, where are described certain experiments with a social theme. Situations involving social conflict were described, and subjects asked how these would eventuate. Would the merging religious factions stay united?—and so on. Here, too, the process of timing and the point of no return are shown to exist.

Both in the ingenious experiments and in the more theoretical discussions Bartlett does not claim quantitative results or any kind of finality. As in his earlier book, "Remembering" (Cambridge, 1932), the experiments are simple, but the rewards great. The thought is powerful, but in parts not easy to follow. This is a notable book on a subject of great complexity; it will be read for many years to come.

GEORGE HUMPHREY

MEASUREMENT OF THE NEUTRON SPECTRUM FROM ZETA

By B. ROSE, A. E. TAYLOR and E. WOOD
Atomic Energy Research Establishment, Harwell

THE energy spectrum of neutrons emitted from ZETA[1] has been studied using a high-pressure diffusion cloud chamber to obtain information on the mean velocity in the laboratory reference system of the centre of mass of the interacting D–D system. If the mean velocity were to be zero, this would provide additional evidence that the neutrons produced by ZETA were due to a thermonuclear process. The work was begun in mid-February 1958 and measurements were completed by the end of March.

The experimental layout is shown in Fig. 1. *A* is the torus in which the discharge occurs. *B* is a 2-ft. long polyethylene collimator the aperture of which tapers from 4 in. wide × 8 in. high at the torus end to 8 in. wide × 6 in. high at the other, *C* is a 16-in. thick concrete shielding wall containing a further collimating aperture *D* 15 in. wide × 2½ in. high, and *E* is the 18-in. diameter cloud chamber, the centre of which is 9 ft. 9 in. from the centre line of the torus. The sensitive volume of the chamber is shown shaded.

B and *D* were arranged so that the discharge was viewed tangentially through a gap between the stabilizing field windings *F*, and the effective fraction of the discharge 'seen' by the 2-in. sensitive depth of the chamber was approximately 10 per cent. The neutrons passed through 1½-in. aluminium before emerging from the torus. The only sections of the torus wall from which neutrons could be scattered into the cloud chamber were those at either end of the line of sight, and represented only about 1 per cent of the total wall area. This is shown in Fig. 1, where dotted lines indicate the extreme neutron paths. The normal direction in which current flows in the torus is indicated by the heavy arrow.

In order to enhance any effect due to the direction of the discharge current, measurements were also made with the discharge current and direction of the stabilizing field reversed. For the calibration runs, which were made with a pulsed weak D–D source located at *G*, the neutrons detected were those which had been emitted at 90° to the direction of bombarding deuterons of energy 20 keV.

Stereoscopic photographs were taken of the chamber approximately 100 msec. after the ZETA pulse or the pulse from the D–D source, and the neutron spectrum was determined from measurements of the range and direction of the recoil protons made on the re-projected image. The chamber was operated at a pressure of approximately 110 lb./sq. in. with the mean gas temperature in the sensitive region about −30° C., so that the maximum range of a recoil proton from

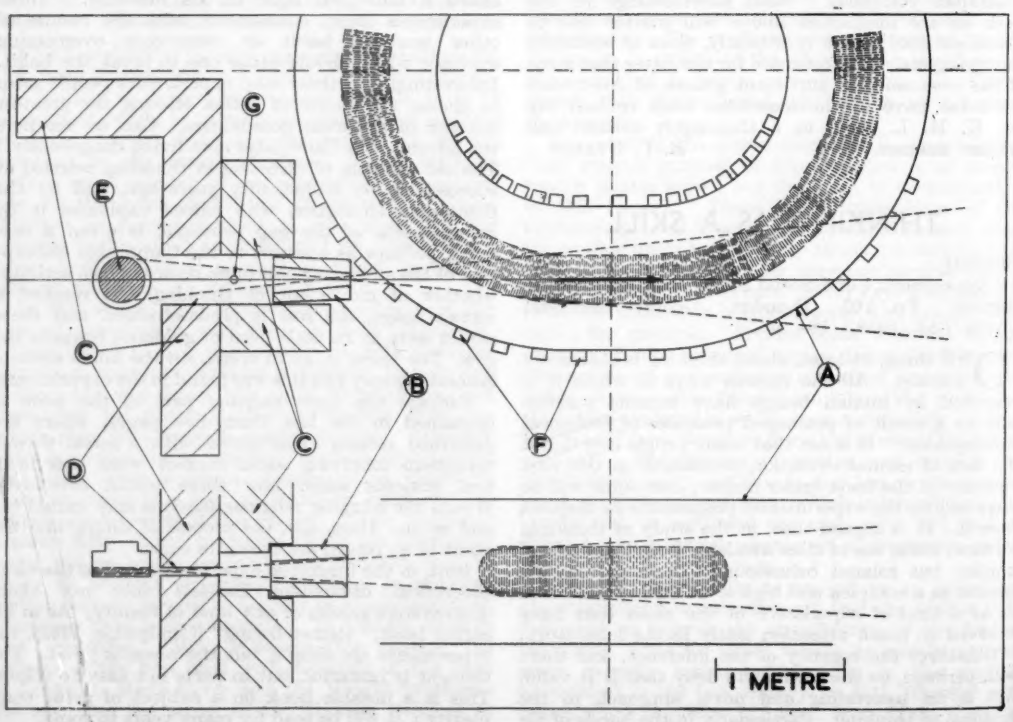

Fig. 1. Experimental arrangement

Table 1

Date		1.3.58	13.3.58	15.3.58	Remarks
No. of accepted proton tracks	Normal	19	17	11	
	Reverse	2	17	22	
Total neutron production per ZETA pulse ($\times 10^{-6}$)	Normal	3·4	1·8	1·1	From cloud chamber
	Reverse		1·2	1·2	
	Normal	3·0	1·6	1·8	From calibrated neutron counters
	Reverse		1·7	1·9	
					Mean values
Mean energy of group (MeV.)	Normal	2·30 ± 0·03	2·34 ± 0·035	2·40 ± 0·03	2·33 ± 0·02 Weighted by number of tracks
	Reverse	2·69 ± 0·08	2·65 ± 0·035	2·67 ± 0·025	2·66 ± 0·02
Observed S.D. of single determination (MeV.)	Normal	0·11 ± 0·02	0·13 ± 0·025	0·08 ± 0·02	0·115 ± 0·014 Derived from internal consistency
	Reverse		0·115 ± 0·025	0·10 ± 0·02	0·110 ± 0·014
Difference between normal and reverse runs (MeV.)		0·39 ± 0·09	0·30 ± 0·05	0·27 ± 0·04	0·29 ± 0·03 Weighted by inverse variances
Mean energy of normal and reverse		2·49 ± 0·045	2·50 ± 0·025	2·50 ± 0·025	2·50 ± 0·02
Charging voltage (kV.)		23	20	22	Less than 10 per cent of neutrons produced by voltage transients at end of current pulse
Secondary current (amp.)		$1·9 \times 10^3$	$1·7 \times 10^3$	$1·7 \times 10^3$	
B_z field (gauss)		160	160	160	
(D_2 + 5 per cent N_2) pressure (μ)		1/8	1/8	1/8	
D–D calibration runs					
Date		5.3.58	7.3.58	13.3.58	
No. of accepted proton tracks		16	10	11	
Mean energy of group (MeV.)		2·495 ± 0·03	2·495 ± 0·05	2·43 ± 0·04	2·45 ± 0·022 Weighted by number of tracks
Observed S.D. of single determination (MeV.)		0·11 ± 0·02	0·14 ± 0·03	0·12 ± 0·03	0·125 ± 0·016

a 2·5-MeV. neutron was approximately 4·5 cm. The range – energy relation for protons in hydrogen was calculated, and the ranges of proton recoils from the D–D neutrons used to determine the mean density of gas in the cloud chamber. A check on the calibration was found in the presence of occasional α-particles from radioactive contamination of the chamber, the ranges of which agreed well with those to be expected from radon and thoron.

Within the poor statistics available, the only systematic variation of neutron energy with position of the proton track was a possible 3 per cent change over the depth of the chamber. No correction was applied for this effect.

Adopting a compromise between yield and accuracy of measurement of neutron energy, tracks were accepted only if the proton energy exceeded 1·46 MeV. and the proton recoil angle was less than 40°. All tracks which had indecisive ends (which could be produced by entering a region of vapour depletion, or by leaving the sensitive volume) and all heavy tracks (which could be α-particles) were also rejected. Roughly one proton track per 15 ZETA pulses was accepted.

The error in the estimate of the neutron energy from a typical track was about 4 per cent, compounded from the errors in measuring range (1½ per cent), scattering angles (2 per cent), the uncertainty in the direction of the incident neutron due to the angular resolution of the collimator (2½ per cent), variation of density in the cloud chamber (1½ per cent) and other smaller effects. From the number of recognized α-particle tracks, it is estimated that less than 5 per cent of the tracks included in the analysis were unrecognized α-particles.

The combined results are shown in Fig. 2. The tracks cluster into fairly tight groups; the mean energy of the ZETA neutrons in each of the normal and reverse directions is clearly different from that of the calibrating D–D source, and the sign of the energy shift is dependent upon the direction of the discharge. It is of interest that the observed differences of energy are similar to those observed by Hagerman and Mather[2] in a linear discharge.

In Table 1 are listed various quantities derived from the measurements and also the operating conditions for the various runs.

The agreement between the total neutron production as measured with calibrated neutron counters,

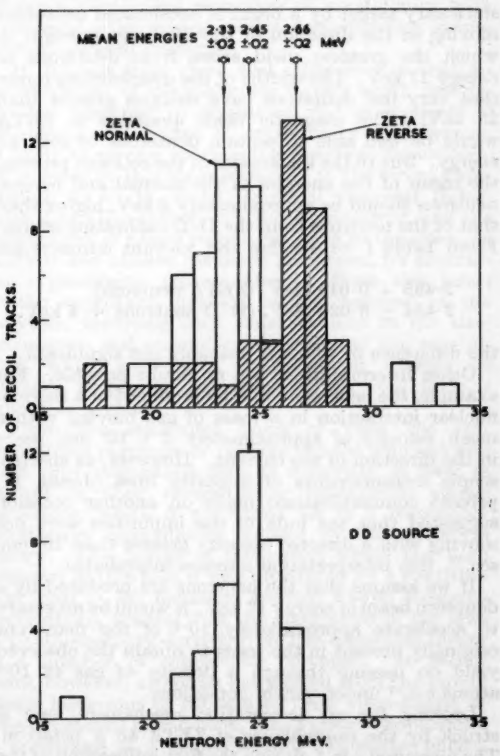

Fig. 2. Histogram of neutron energies corresponding to observed proton tracks

and as calculated from the frequency of proton recoils in the cloud chamber, is satisfactory to within the uncertainty of a factor of 2 in the latter calculation, which was based on the assumption that the neutrons originate in the discharge. If they had originated uniformly over the torus wall, there would have been a discrepancy factor of 10.

Mean energies were calculated for the individual runs and standard errors derived from the internal consistency of the measurements, only values within 0·30 MeV. of the mean energies being included in the analysis. All the 'normal' runs were consistent with a single mean energy, as were the 'reverse' runs. The observed standard deviation on a single determination was in satisfactory agreement with the figure of 4 per cent estimated from the known errors of measurement and was no worse than that observed in the calibration runs. This suggests that the individual neutron groups did not have a spread of energy greater than approximately 100 keV.

The fact that the mean energies of the 'normal' and 'reverse' runs are different is inconsistent with the hypothesis that all the neutrons are produced by a thermonuclear interaction in a mass of gas which is at rest in the laboratory system. The extent of the overlap of the two neutron groups (Fig. 2) is consistent with the hypothesis that none of the neutrons is produced by such a thermonuclear process, though the instrumental resolution is, of course, inadequate to exclude the presence of a small 'thermonuclear' contribution.

The mean energy shift of 290 keV. is most simply interpreted as a result of the bombardment of a stationary target by a beam of accelerated deuterons moving in the direction of the discharge current, in which the greatest yield arises from deuterons of energy 17 keV. The widths of the distributions imply that very few deuterons have energies greater than 25 keV. The magnetic fields available in ZETA would be well able to contain deuterons of such an energy. Due to the kinematics of the collision process, the mean of the energies of the normal and reverse neutrons should be approximately 4 keV. higher than that of the neutrons from the D–D calibrating source. From Table 1 we see that the relevant numbers are

$2{\cdot}495 \pm 0{\cdot}015$ MeV. (ZETA neutrons)
$2{\cdot}454 \pm 0{\cdot}022$ MeV. (D–D neutrons + 4 keV.)

the difference of which is probably not significant.

Other interpretations are no doubt possible. For example, the neutrons could be produced in a thermonuclear interaction in a mass of gas moving with a mean velocity of approximately 6×10^7 cm. sec.$^{-1}$ in the direction of the current. However, as spectroscopic measurements of impurity lines (Jones, B., private communication) made on another occasion suggested that the bulk of the impurities were not moving with a directed velocity greater than 10^6 cm. sec.$^{-1}$, this interpretation appears improbable.

If we assume that the neutrons are produced by a deuteron beam of energy 17 keV., it would be necessary to accelerate approximately 10^{-6} of the deuterons originally present in the torus to obtain the observed yield on passing through a density of gas of 10^{14} atoms c.c.$^{-1}$ under 'pinch' conditions.

Looking for an acceleration mechanism, one is struck by the resemblance of ZETA to a betatron. The measured e.m.f. during the first millisecond of the discharge is $1\frac{1}{2}$ V.cm.$^{-1}$ and the resistive part could well be 1 V.cm.$^{-1}$. An electric field of only $\frac{1}{2}$ V.cm.$^{-1}$ would accelerate deuterons *in vacuo* to 17 keV. in the $\frac{1}{4}$ m.sec. which elapses between the initiation of the discharge and the onset of neutron production. It seems plausible, therefore, to assume that some deuterons in the surface layer of the discharge will be so accelerated.

When the axial electric field is first applied, the gas is weakly ionized, and some of the deuterons present will be accelerated to an energy of 1–3 keV. before the ionization is complete. This phase lasts from the beginning of the discharge for about 70 μsec. In the second phase, from 70 to 1,000 μsec., the discharge current builds up to a maximum and the pinch develops. Calculation of the relaxation times according to the theory of Spitzer[3] indicates that deuterons which have already been accelerated will continue to gain energy if the electron temperature is greater than or equal to 10^6 degrees K. Slow deuterons will not, however, be able to accelerate, principally because of the retardation by D–D collisions.

In the third phase, with the pinch fully developed and the applied e.m.f. low, the deuterons may slowly lose energy, but the time for slowing down could well be several milliseconds. During this time, therefore, the deuterons are constrained by the magnetic field to circulate around the torus within the discharge, and will continue to produce neutrons so long as the discharge is maintained.

This mechanism will account qualitatively for the fact that the neutron yield decreases with increasing gas pressure[1], for the numbers accelerated in the first phase will be very sensitive to pressure. It would account for the fact that the introduction of the 1-in. diameter magnetic field probe reduces the neutron production[1], by simple mechanical obstruction of the beam.

We conclude, therefore, that the neutron spectra observed may be interpreted in terms of an acceleration process, for which a mechanism is proposed, and suggest that the majority of the neutrons from ZETA are not produced by a thermonuclear process. Consequently, doubt is cast upon the temperatures derived from the yield of neutrons, except to provide an upper limit.

However, as the thermonuclear yield of neutrons increases approximately as the eighth power of the absolute temperature in the range 1–10^8 degrees K., the present results are compatible with temperatures of the order of those reported previously[1]. For example, a reduction of the temperature by 30 per cent would reduce the thermonuclear neutron yield to only 6 per cent, and the possibilities of the presence or absence of a 6 per cent 'thermonuclear group' of neutrons is beyond the accuracy of the present experiment to decide. The evidence for such high temperatures in ZETA must, however, be based on the spectroscopic measurements and not on the neutron yield.

It is a pleasure to thank fellow-members of the Cyclotron Group, Messrs. Bird, Dolley and Thorpe, for much assistance, and Mr. B. Ward of the ZETA group, who worked very hard on our behalf with the D–D source. We are grateful to many members of the ZETA group for their co-operation, and to Mr. R. S. Pease, Dr. P. C. Thonemann and Dr. W. B. Thompson for many stimulating discussions.

[1] Thonemann, P. C., *et al.*, *Nature*, **181**, 217 (1958).
[2] Hagerman, D. C., and Mather, C. W., *Nature*, **181**, 226 (1958).
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PHYSICS OF HIGH-MOLECULAR MATERIALS

THE concept of a high polymer as a substance composed of molecules of chain-like form built up by the continuous addition of one or more simple units is now so familiar that it is difficult to realize how recent are the scientific developments by which its validity has been established. In the case of rubber, for example, although Faraday had established its empirical formula as early as 1826, and Joule and Kelvin had discussed its unusual thermo-elastic properties in the middle of the century, the question whether its molecular weight was of the order of 1,000 or of the order of 1,000,000 was still under discussion less than twenty years ago. However, since that time, and particularly since the revolutionary change in viewpoint brought about by the emergence of the statistical approach to the problems of polymer chemistry and polymer physics, associated particularly with the names of K. H. Meyer, W. Kuhn, P. J. Flory, H. Mark and E. Guth, progress in this field has been extraordinarily rapid, and the impact of this progress on industrial technology has been a factor of major economic importance.

The occasion of the Silver Jubilee Symposium on the "Physical Properties of Polymers" held in London during April 15–17 to mark the twenty-fifth anniversary of the formation of the Plastics and Polymer Group of the Society of Chemical Industry provides a suitable opportunity to look back and survey the changes which have taken place during this period and also to attempt to assess the trend of development at the present time.

Polymer science may be said to be a product of colloid chemistry, and it is natural that in the earlier stages of its development the problems of the determination of the chemical structure of polymers dominated the field. However, it soon became apparent that the interpretation of their physical properties presented a challenge of equal scientific interest, so that to-day this side of the subject is attracting an increasing amount of attention. Indeed, the outstanding impression created by the current phase of development is the wide range of variation of properties which may be achieved by changing the physical state of a polymer of a given basic chemical composition, by modifying the conditions of polymerization so as to control the degree of chain regularity, branching, etc., and hence the susceptibility to crystallization.

Basically, polymers may be divided into three broad groups. These are first, the soft amorphous polymers or rubbers; secondly, the hard amorphous polymers or organic glasses; and thirdly, the (partially) crystalline polymers, which have physical properties intermediate between the rubbers and the glasses. Each of these classes represents a particular physical state, and these states are closely analogous to the corresponding liquid, glassy (supercooled liquid) and crystalline states of low-molecular materials. While it is known that many polymers (including natural rubber) may by suitable treatment be brought into two and sometimes all three of these different states, it has nevertheless, until recently, been practically useful to regard any given chemical type as belonging effectively to one or other of these classes. With the introduction of new types of catalyst (Ziegler catalysts), however, this classification is beginning to break down, for not only is the range of crystallinity capable of considerable modification (as in polyethylene and polypropylene) but also substances such as polystyrene which have hitherto been thought of as essentially amorphous may be brought into the crystalline state. These 'isotactic' polymers are believed to owe their properties to a perfectly regular sequence of 'head-to-tail' addition of monomer units in a single chain, as distinct from the random arrangement, together with chain branching, which follows from the more usual processes. Another factor which may affect the physical properties of a polymer, either through its effect on crystallinity or otherwise, is the degree of cross-linking. To effect cross-linking by chemical means it is necessary that the polymer chain should contain a suitable reactive site for chemical attack. Materials which are fully saturated or non-reactive cannot be cross-linked chemically without the introduction of a second component, which is frequently a disadvantage. It has been found, however, that in many cases cross-linking may be effected by subjecting the pure polymer to radiation in an atomic pile, or to high-speed electron bombardment. Polyethylene treated in this way shows a continuous reduction of crystallinity with increasing cross-linking, and a corresponding gradation of physical properties.

It appears from these and other studies that an investigation of the molecular factors which determine the tendency to crystallize, and of methods of estimating the degree of crystallinity in polymers, is likely to assume considerable practical importance. In a paper on this topic presented to the recent Symposium by C. W. Bunn (Imperial Chemical Industries, Ltd.) this subject is critically reviewed, and the possibilities of newer techniques, such as the infra-red method and nuclear magnetic resonance, for estimating crystallinity, are considered. Bunn also refers to the important question of the 'texture' of the polymer, involving such considerations as the size, orientation and mutual arrangement of the crystallites, which may have an important bearing on physical properties, but about which very little is known at present.

From the structural point of view the soft amorphous polymers or rubbers are the simplest and most fully understood class of materials, at least in respect of their reversible or equilibrium elastic behaviour, which is accounted for in a reasonably satisfactory quantitative manner by the statistical theory. The degree of refinement which has been achieved in this field is well illustrated by a contribution from D. W. Saunders (British Rayon Research Association), dealing with the application of the laws of photo-elasticity derived from the statistical theory to a number of rubber-like polymers. In recent years, however, attention has shifted from the purely elastic behaviour of rubbers to their visco-elastic or time-dependent phenomena, which assume importance in conditions of dynamic loading (vibration phenomena, etc.).

In this province there is at present no general molecular theory available, and it is necessary to fall

back on more empirical methods of approach. The most usual type of treatment, illustrated by a number of contributions to the Symposium, is related to the method of 'reduced variables' introduced by Ferry and his associates. According to this method the response of the material to an oscillating stress (for example, dynamic modulus and loss angle) is studied over as wide a range of frequency as possible, and at a number of temperatures. It is then found that a change of frequency is equivalent to a change of temperature (the precise relation between these two variables depending on the material), and hence it is possible to construct a single 'master curve' which may be regarded as representing the properties of the material over the whole of the range of variables covered. This set of data should then, in principle, enable the behaviour of the material under any arbitrary conditions of stress and temperature to be predicted. In the Symposium the application of this method, not only to the mechanical properties but also to the formally analogous electrical properties, was discussed by A. R. Payne (Research Association of British Rubber Manufacturers). Other contributors emphasized the limitations of the method, particularly when large strains are encountered, and in crystalline materials, where more complex structural changes appear to accompany the application of even quite small stresses.

Although not based on a molecular theory, the study of dynamic properties by these methods may nevertheless reveal, through the overall pattern of the so-called 'relaxation spectrum', regions of transition which can be associated, at least tentatively, with specific molecular processes. Notable among these are the region corresponding to the transition from the rubber-like to the glassy state, which is present in both crystalline and amorphous polymers, and the region in which melting of the crystallites occurs. Other transitions indicating the onset of a restricted rotation or local movement of side groups may also appear, and the following up of such phenomena by systematic variation of the chemistry of the polymer, as in the work of E. A. W. Hoff and W. Reddish (Imperial Chemical Industries), opens up interesting possibilities.

From the more immediately practical contributions to the Symposium an impression is gained of the increasingly severe range of requirements which plastics and other high polymers are expected to satisfy. Of particular interest are the 'expanded' light-weight materials required in the aircraft industry, and for thermal insulation at very low temperatures; these were discussed by G. C. Ives and J. A. Mead (Dr. V. E. Yarsley (Plastics Testing Laboratories), Ltd.). Another important practical property, dealt with by G. Hulse (Monsanto, Ltd.), is resistance to shock or impact; this is a subject in which the specification of a suitable method of testing may present formidable difficulties. In the electrical industry, the need for dielectrics capable of withstanding high voltages calls for much work in the study of the initiation of discharges and methods of estimating durability under a variety of operating conditions; this field of inquiry was treated in contributions by N. Parkman (Electrical Research Association) and by G. C. Ives and M. M. Riley (Dr. V. E. Yarsley (Plastics) Testing Laboratories, Ltd.).

From the various lines of work referred to in this brief review it is clear that the range of polymer materials available both for scientific study and for practical utilization continues to expand at an increasing rate, and that there is no sign at present that this process is in any sense approaching saturation. If it should continue in the next twenty-five years as it has in the last, the possibilities are, to say the least, interesting. L. R. G. Treloar

UTILIZING THE NATURAL RESOURCES OF LAKE VICTORIA FOR THE BENEFIT OF FISHERIES AND AGRICULTURE

By R. S. A. BEAUCHAMP

East African Fisheries Research Organization, Jinja, Uganda

A SHORTAGE of sulphates in solution is a factor affecting the productivity of Lake Victoria. This was discovered by growing cultures of algae in known amounts of lake water to which were added solutions containing all but one of the essential plant nutrients and then observing the growth made in these various media[1]. The usual method for determining chemical deficiencies by observing the reduction of chemical substances in solution and relating them to the growth of the plankton is not applicable in Lake Victoria, because under the tropical conditions obtaining, seasonal fluctuations in the plankton are slight and because throughout the year the amount of sulphate in the Lake water is too low to be readily detectable by chemical means.

As sulphates are present in most waters of the world in quite high concentrations, the discovery that they were a limiting factor in Lake Victoria was a matter of considerable interest.

A study of the records made by water analysts in different areas of Africa revealed that in many African lakes and streams sulphates are present in only very small amounts[2]; I suggested that this might indicate that sulphates were in short supply in the soils through which these streams drain. Several agricultural departments in East Africa have since found that many soils in Uganda, Kenya and Tanganyika contain only a little sulphate; apart from references to this in current annual reports, their results have not yet been published. It seems, moreover, that in some cases where fertilizer trials with ammonium sulphate and superphosphates have led to increased production of crops, part of the increased yield has been due to the sulphate contained in these fertilizers. Applications of gypsum in the Kitale area of Kenya have led to increased yields, particularly of leguminous plants used for fodder. Although all these investigations are only in an early stage, there are clear indications that many African soils contain too little sulphate for maximum production.

So far as the work of the East African Fisheries Research Organization was concerned, it was obviously of great importance to investigate the sulphur cycle

in Lake Victoria. Analyses showed that the streams flowing into the Lake contained little or no dissolved sulphate, and that very little is contained in the rain falling on the Lake. It was found, however, that the bottom deposits[3] contain very considerable amounts of sulphur, both in the form of sulphates and as organically combined sulphur. Only a little is present in the form of sulphides. Values for total sulphur as high as sixteen thousand parts per million (dry weight) were recorded, and values of eight thousand parts per million were of common occurrence in the mud deposits in sheltered bays.

Further analyses of these mud deposits showed that they contained very little inorganic matter, and much that might be described as inorganic was in fact composed of diatom frustules. These frustules are, it seems, responsible for the high values for sulphate contained in the mud, as they have the capacity to adsorb sulphates and prevent their reduction to sulphides.

More than 90 per cent of the sulphur contained in the mud deposits is, however, organically combined. We thus find that sulphur is strangely distributed within the Lake, with the water overlying the mud containing less than one part per million, whereas the mud itself contains many thousands of parts per million.

A peculiar feature of these deposits is that they do not decompose, or if they do, they do so extremely slowly. Either *in situ* or if brought into the laboratory and kept either aerobically or anaerobically, they show little tendency to decompose or break down in any way. However, this mud, if dried and rewetted or if boiled, produces a very fertile medium in which bacteria grow profusely; aqueous extracts derived from it can be used to grow a variety of micro-organisms and cultures of algae. Microscopical examination of these deposits show that they contain enormous numbers of minute, immobile encapsulated organisms, related, it seems, to certain primitive forms of blue-green algae or to *Nocardia*-like organisms. Herein lies a probable explanation for the fact that these highly organic deposits do not decompose in the way one might expect.

These deposits are composed in the first place of precipitated plankton, plant detritus and excreta of fish and other animals. Evidently, this material provides conditions that are extremely favourable to the growth of these encapsulated organisms. They become dominant in the mud and seem to prevent in some way the growth of other micro-organisms, while they themselves appear to be resistant to the normal processes of decay. It is of interest to record that these minute organisms are not readily visible until the deposits have been well shaken with glass beads. In the natural state they bind the other organic material into small aggregates composed of detritus, algal cells, etc.

Another property of the mud which was discovered on analysis is its very high nitrogen content; later it was found that much of this nitrogen is in the form of protein, and values for crude protein as high as 20 per cent have been recorded[4].

Spectrographical analyses[5] of these deposits have shown that they contain in considerable amounts all the trace elements required by both plants and animals as well as the usual mineral requirements.

As can be seen from the above brief account, the bottom deposits of Lake Victoria, which are of great extent and depth particularly in the sheltered coastal areas, contain vast quantities of organic matter, rich in plant nutrients. They contain large quantities of organically combined sulphur, which is a known deficiency in the Lake water and which is a suspected deficiency in many African soils. The problem that awaits solution is how best these deposits can be utilized for the benefit of both fisheries and agriculture.

Before outlining any major development projects, it may be as well to consider first the effect of man's activities on the natural biological cycle as it occurs in Lake Victoria.

In the early part of the century, modern fishing gear was introduced, notably gill nets. These nets when first set in the Lake caught very large numbers of fish, particularly so with regard to the two species of *Tilapia* endemic to the lake, *T. esculenta* and *T. variabilis*. These fish are still the most important element in the commercial fishery. Though reliable records were not kept, it is certain that the Lake supported in those earlier days populations of *Tilapia* much more numerous than at present. The abundance of large *Tilapia*, of a size to be caught in 5-in. gill nets, indicated that there were accumulated stocks belonging to many year-groups.

The more numerous of the two species of *Tilapia* is *T. esculenta*; both are herbivorous and feed mainly on the phytoplankton. They thus, as converters of plant material into animal material, play a very important part in the general economy of the Lake. It follows that a reduction in the numbers of these fish will mean that less phytoplankton is consumed and more will be lost by precipitation to the bottom of the Lake where, as shown above, it becomes unavailable and is not even liable to decomposition in a way that would restore the nutrient status of the water. There is no doubt that the general fertility of this Lake depends on the maintenance of large stocks of these herbivorous fish. Unfortunately, intensive gill-net fishing over the past fifty years has greatly depleted the stocks of *Tilapia*.

Investigations carried out by the East African Fisheries Research Organization indicate that there is still an abundance of phytoplankton which could support much greater numbers of *Tilapia* than occur at present. Studies on the life-history of these fish indicate that the most important factor limiting their numbers is a shortage of suitable spawning sites. These fish require a firm substratum, inshore and in moderately sheltered water, where they can make nests in which the eggs are spawned and fertilized. After fertilization, the eggs are carried in the mouth of the female and 'brooded' for about three weeks, by which time the fry have completely resorbed their yolk sacs. The brooding females retire to sheltered waters on the fringe of water-lily swamps, where the fry are eventually abandoned. Eventually, these fry migrate away from the margins of the Lake and feed on the plankton in the more open waters of these sheltered bays. They do not, until much older, move far from where they were spawned.

The shortage of suitable spawning sites arises from the fact that much of the littoral region is overgrown with papyrus swamps. The water in these swamps is without oxygen, and is unsuitable for fish without accessory air-breathing organs. These papyrus swamps frequently extend some distance into the Lake over several feet of water, floating at the surface as a dense mass of vegetation. Beyond the fringe of the papyrus, the bottom is composed of soft

mud; thus the *Tilapia* in such regions can find few suitable areas on which to make their nests.

As an immediate expedient to overcome the present shortage of fish, it has been recommended that a vigorous policy of re-stocking should be adopted. *Tilapia* can be reared quite easily in shallow ponds. If these ponds are managed solely as breeding ponds, and not as ponds for growing fish to edible size, great numbers of fry can be reared annually and liberated to grow to full size in the Lake. Some pilot experiments have already been carried out along these lines. In these experiments, *T. zillii*, which were bred from a few individuals taken from Lake Albert, were used because it was thought that these fish, which eat higher plants, would not interfere with the two endemic plankton-feeding species; and furthermore, it was thought that they might have a beneficial effect by reducing the amount of littoral vegetation. The results of these experiments have been encouraging, and fry which have been introduced have grown to commercial size in just over two years. *T. zillii* appears to grow rather faster than either *T. esculenta* or *T. variabilis*. However, a good case can be made out for re-stocking the Lake with fry of *T. esculenta* as well.

Re-stocking can only be considered as a partial solution to the problem of increasing the numbers of fish in Lake Victoria; a more adequate solution would seem to lie in a policy of swamp clearance and reclamation. Papyrus swamps should be cleared in places where they are not too extensive and where such clearance would uncover areas suitable for nest-building by *Tilapia*. Furthermore, a coast-line cleared of excessive vegetation would certainly provide better conditions for the young fry. Part of the cost of swamp clearance might be recovered by making compost of the papyrus, and some of the other aquatic plants and grasses might be converted into silage for cattle.

A distinction should be drawn between a policy of swamp clearance, as outlined above, and a policy of swamp reclamation. There are many places, particularly on the north coast of Lake Victoria, where former shallow enclosed bays have become entirely choked with vegetation composed partly of papyrus and partly of swamp grasses. Such areas, which are already in the process of becoming dry land, might be reclaimed quite easily by pumping on to them fertile Lake mud with the aim of converting them into productive market gardens. This might be done economically where there is a high demand for food in areas close to townships. Fertile water draining into the Lake from these reclaimed and cultivated areas should lead to an increase in plankton production and so to an increased production of fish. This type of swamp reclamation would have the added advantage of eliminating places where mosquitoes can breed and so lead to a reduction in the incidence of malaria.

Looking rather further afield for ways of utilizing the bottom deposits of Lake Victoria, it seems that it may be worth while to pump this mud from the bottom of the Lake, dry it and use it elsewhere as an agricultural fertilizer. Some preliminary trials have shown that good results may follow the application of this mud to infertile soils, but it has yet to be determined whether this can be done on a commercial basis.

Some trials have been made to see whether Lake mud could be used as a food for pigs. The high protein content of the mud suggested that this might be feasible; in this connexion it is perhaps worth recording that significant quantities of vitamin B_{12} are contained in the mud[4]. Pigs tolerated up to 20 per cent of this mud in their food. Over the period of the experiment, which was from shortly after weaning until they went to the bacon factory, approximately 10 per cent of their normal rations were withdrawn and made up with mud. Five out of the six pigs used in this experiment were classed by the factory as grade '*A*'. Their growth-rate was, however, slightly slower than normal. This experiment cannot be considered as adequately controlled, but it did show that there is some possibility of using this mud as a food.

Very carefully controlled feeding experiments were carried out on rats; in this case it was found that these animals could make no use of the protein contained in the mud. As explained above, most of this protein is probably contained in the very small encapsulated blue-green algae which comprise the main living constituents of the mud. These have a very resistant cell-wall which appears to defy digestion by most animals. Future research may find a way to process this mud so as to make the protein more available.

In this short article, it has not been possible to do more than outline briefly a number of possibilities; it is hoped, however, that future research and the application of this research may lead to the planning of a programme of development that will make good use of the natural resources of Lake Victoria.

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NEWS and VIEWS

Geography at the London School of Economics: Prof. L. Dudley Stamp, C.B.E.

Prof. L. Dudley Stamp, having reached the age of sixty, has decided to retire from active teaching at the London School of Economics at the end of the present academic year in order to devote himself more fully to the work of the International Geographical Union, of which he was president during 1952–56, and especially to the further organization of the World Land Use Survey sponsored by the Union. Prof. Stamp has held the chair of social geography, the only one of its kind in Britain, since its inception in 1948, and has been concerned primarily with the application of methods of geographical survey and analysis to practical problems especially in the sphere of town and country planning. He organized the Land Utilization Survey of Britain in 1930 and continued to direct the work, which involved a field-to-field survey of land use in England, Wales and Scotland, and the issue of one-inch maps with explanatory "County Memoirs". He was vice-chairman of the Scott Committee, 1941–42; chief adviser on rural land use to the Ministry of Agriculture, 1942–55; and is currently serving on the Royal Commission on Common Land, on the

Nature Conservancy, and as United Kingdom delegate to the Land and Water Use Sub-Commission of the European Committee for Agriculture with the Food and Agriculture Organization of the United Nations.

Dr. M. J. Wise

Dr. M. J. Wise has been appointed to a new chair of economic geography in the University of London, tenable at the London School of Economics. The chair of social geography held by Prof. Stamp was established to develop studies in a new field; that now to be filled by Dr. Wise will continue and extend studies in the borderland between economics and geography. Dr. Wise graduated with honours in geography at the University of Birmingham in 1939, and served in the Royal Artillery and Northampton Regiment during the War, being awarded the Military Cross in 1945. After a period as lecturer at Birmingham (1946–51), he has been successively lecturer and Sir Ernest Cassel reader in economic geography at the London School of Economics. On the occasion of the British Association meeting in Birmingham in 1950 he edited "Birmingham and its Regional Setting", and has published numerous papers on the industrial development of the Black Country.

The Wellcome Foundation Ltd.: Dr. R. S. F. Hennessey, C.M.G.

Dr. R. S. F. Hennessey, head of the Wellcome Laboratories of Tropical Medicine since 1956, has been appointed to the newly created position of head of the Therapeutic Research Division of the Wellcome Foundation Ltd. Dr. Hennessey graduated in medicine at Trinity College, Dublin, in 1927 and later studied bacteriology and tropical medicine at the London School of Hygiene and Tropical Medicine. He joined the Colonial Medical Service in 1929 and worked as a pathologist in Uganda and Palestine. After a period as deputy director of the Palestine Department of Health, Dr. Hennessey served as an assistant medical adviser at the Colonial Office. He was director of Medical Services in Uganda during 1949–55 and chairman of the African Regional Committee of the World Health Organization during 1953–54. He has published many observations on various aspects of tropical disease including reports on typhus fever and plague. Dr. Hennessey thus brings to his new appointment, which involves coordination of the work of the chemical, chemotherapeutic and pharmacological research laboratories, which comprise the Therapeutic Research Division of the Foundation, both administrative experience and practical knowledge of the problems of research.

Wellcome Laboratories of Tropical Medicine: Dr. L. G. Goodwin

Dr. L. G. Goodwin, who has been appointed head of the Wellcome Laboratories of Tropical Medicine in succession to Dr. Hennessey, graduated in physiology and medicine at University College, London, and also obtained degrees in pharmacy and pharmacology. He joined the Wellcome Bureau of Scientific Research as pharmacologist in 1939 after holding an appointment at the School of Pharmacy, University of London, and later became head of the Chemotherapy Department of the Wellcome Laboratories of Tropical Medicine. In addition to laboratory investigations, Dr. Goodwin has carried out field studies in East and West Africa and has been responsible for valuable reports on the action of drugs in parasitic infections, particularly leishmaniasis, malaria and helminthiasis. His publications include contributions to monographs on biological standardization and protozoal infections.

Department of Scientific and Industrial Research: Financial Statement

The first report of the Council for Scientific and Industrial Research covering the period November 7, 1956, to December 31, 1957, takes a somewhat shorter form than the customary reports of the previous Advisory Council. The Lord President contributes an introduction, but the Council's report, which is discussed elsewhere (p. 1623), is supported by rather brief summaries of progress of research in the several stations of the Department and by the customary summary of expenditure, list of assessors, research associations, research studentships awarded and particulars of research grants. The work of the grant-aided research associations, which received £1,424,830 in annual grants and £126,954 in special grants, compared with £1,423,775 and £373,028, respectively, in 1955–56, is being summarized in a separate publication.

The Department's gross expenditure of £8,255,561 compares with £7,350,738 in the previous year and is reduced to £7,249,843 by various receipts (£437,099 being from the National Physical Laboratory) for work done for Government departments or for industry, the net increase in 1955–56 being £821,150. The staff of the Department at January 1, 1958, was 4,751 (including 211 part-time), an increase of 96 on the previous year. Grants to students amounted to £317,347, a further decrease of £2,572, the number of students in training in 1956 being 1,006, and in 1957, 1,301, and of these 404 in 1956 and 649 in 1957 were new. Of seven research fellowships in 1956 and 18 in 1957, four in 1956 and 13 in 1957 were new, and 46 grants for special researches in 1956 and 115 in 1957 brought the total of such grants to 99 and 193, respectively, compared with 53 in 1955. Of the grants for special researches, 54 in 1956 and 88 in 1957 were in physics; for chemistry, the figures were 14 and 38; for biology and biochemistry, 7 and 17; for geology, 8 and 12; for mathematics, 7 and 14; for engineering, 5 and 12. In 1956 chemistry claimed 372, and in 1957 466, of the students receiving grants; in physics the corresponding figures were 256 and 305; in biology and biochemistry, 108 and 150; in mathematics, 96 and 118; in geology, 43 and 73; in chemical engineering and metallurgy, 58 and 78; in engineering, 42 and 57; in electrical engineering, 26 and 40; and in social sciences, 5 and 14.

Expenditure on the National Physical Laboratory of £1,075,130 gross was slightly more than in 1955–56 (£946,890) and, with the exception of food investigation, expenditure on which decreased to £321,100 from £364,472 in the previous year, there were increases in expenditure on all branches of the Department's activities, notably on road research (£441,762 net, compared with £388,436 in 1955–56), on fuel research (£330,502 compared with £288,260), the Chemical Research Laboratory (£160,404 compared with £139,226) and mechanical engineering research (£486,931 gross, compared with £455,326). Some of the other increases, though smaller, were high proportionally as the following net figures show,

those for the previous year being in brackets: building research, £521,065 (£492,701); forest products research, £128,256 (£116,161); geological survey and museums, £282,370 (£268,260); pest infestation, £83,341 (£72,284); radio research, £135,657 (£104,119); and water pollution research, £90,020 (£76,482). Receipts of £73,674 (£53,650 in 1955–56) brought the net expenditure on fire research to £38,745, compared with £31,781, and the increase in gross expenditure on hydraulics research from £100,797 to £123,133 is largely cancelled by an increase in receipts from £16,751 to £31,166. Headquarters, administration, etc., expenditure was £307,436 (£272,551) and headquarters overseas liaison £77,791 (£76,235), while the contributions to European nuclear research increased from £519,996 to £930,000.

Investment in the Power Industries

A White Paper on capital investment in the coal, gas and electricity industries (pp. 8. Cmnd. 415. London: H.M. Stationery Office, 1958. 6*d*. net), which gives the latest information about investment in 1957 and the approved expenditure for 1958–59, notes that the estimated expenditure on electricity (England and Wales) of £235 million in 1957–58 (compared with £233 million and £239 million approved for 1958–59) includes £105 million on conventional power stations and £21 million on nuclear stations; £31 million on main transmission and £83 million on distribution; for 1958–59 the corresponding figures are £90 million; £37 million; £31 million; and £81 million, respectively. The expenditure on nuclear power stations represents continuing work at Bradwell and Berkeley and the commencement of work on a third station at Hinkley Point. Work on new power stations in 1958–59 will be spread over about twenty-six months instead of twenty-four, and the completion of the nuclear power programme described in last year's White Paper will be postponed a year. The expenditure of £19·24 million by the South of Scotland Electricity Board in 1957 and of £26·5 million approved for 1958 includes some £13 million on the nuclear station at Hunterston, accounting for about half the £17 million on generation; and of the North of Scotland Hydro-Electric Board's expenditure of £16·88 million in 1957 and £17·05 million approved for 1958, £13·14 million and £12·4 million, respectively, are on generation, including provision for starting the Strathfarrar and Kilmarnoch scheme and the Loch Awe scheme which are now under consideration. Of the Gas Council and Area Board's estimated expenditure of £56·9 million in 1957–58 and £53·5 million proposed for 1958–59, £0·7 million and £1·1 million, respectively, is for research. Of the National Coal Board's approved expenditure of £100 million for 1958, £83 million has been allocated to colliery developments.

Industrial Research and Development Costs

A comprehensive survey of industrial research and development costs in American industry in 1957—the third in a series begun in 1953—sponsored by the National Science Foundation, is to be conducted by the U.S. Bureau of the Census. The collection of the data by the Bureau of the Census will permit the Foundation to compare research and development statistics with other economic data of industrial firms also gathered by the Census. The survey will be conducted on a sample basis, but none of the published information will reveal the identities of individual reporting firms. The Census requests information on costs of research and development conducted by the reporting company, and that financed by the company but conducted by such institutions as commercial laboratories and universities.

Egyptian Journal of Chemistry

The Chemical Society of Egypt has commenced publication of the *Egyptian Journal of Chemistry*, issued in collaboration with the National Research Centre in Cairo. The editorial board includes professors in the Egyptian universities, the chairman being Prof. A. Riad Tourky. The first number (1, No. 1. Pp. vi+164. Dokki-Cairo, 1958. P.T. 70; 2 dollars) contains twelve papers in pure chemistry and four in applied chemistry, all of high standard. The papers are in English with abstracts in Arabic. We welcome this new journal, which seems likely to find a place among the leading publications in its field.

Commonwealth Telecommunications Board

The ninth General Report of the Commonwealth Telecommunications Board covers the year ended December 31, 1956 (pp. 56. London: Commonwealth Telecommunications Board, 1958). During this year the first trans-Atlantic telephone cable was opened and proved so successful that within a few months plans were made for a second cable to be laid across the Atlantic to Canada as an entirely Commonwealth undertaking, again illustrating the value of Commonwealth co-operation in this field. In November 1956 Canada was directly connected by radiotelephone and radiotelegraphy across the Pacific with Australia and via that country with New Zealand, while in December the Board, as a result of intensive study of the development of the Commonwealth cable network in the light of the developing technique of submarine repeaters, recommended the early convening of a special Commonwealth conference to examine proposals for the provision of repeater submarine telephone cables to carry all types of telecommunications services as the future pattern for the main Commonwealth routes. The partner Governments have since agreed that such a conference should be held in 1958. In comparison with 1955, telephone calls over the Commonwealth communications system increased by about 8 per cent and telegraph traffic by 4·5 per cent. Phototelegraph and telex traffic increased by 22 per cent and 40 per cent, respectively.

The Manchester Museum

The annual report of the Manchester Museum for 1956–57 (Report of the Committee for the year ending July 31st, 1957. Pp. 20. Manchester: The Museum, The University, 1958) states that the main activity during the period has been a continuation of the process of modernization which was initiated a few years ago. Closely associated with this task is the provision of adequate information to enable visitors to understand and enjoy the collections. In spite of television and other attractions, the well-known series of lectures on Saturday afternoons recorded an average attendance of 56. It is estimated that about 100,000 people visit this Museum annually, and it is encouraging to note the amount of published research which is credited to the staff.

Eton College Natural History Society

THE report of the Eton College Natural History Society for 1955–57 (pp. 52. Eton College, 1957. 2*s*. 6*d*.) shows that, during the past two years, there has been an increased number of meetings addressed by speakers expert in their particular fields. In field-work, however, the Society has not been as active as in former years. "A few boys," writes the editor plaintively, "interested in butterflies and birds go on the expeditions with serious intention, but the majority wander aimlessly with no real object." Among the contributions by boys is an article by C. J. Fisher, describing observations made on St. Kilda; an account of a butterfly holiday in Wiltshire by H. M. L. Wade; as well as descriptions of butterflies seen by J. A. Lumley during successive periods of 1956.

Drum Types of Eastern New Guinea

AN important publication of the National Museum of Victoria (Memoirs, No. 22, Part 7 (4th September, 1957): Drum Types of Eastern New Guinea. By Aldo Massola. Pp. 12 (2 plates). Melbourne: National Museum of Victoria, 1957) describes the types of drums from eastern New Guinea. The drums are classified either as with or without handles and an intermediate class of half-handle or elbow. A separate division includes those made of bamboo. The drums are fully described, and with adequate illustrations this paper forms a useful means of identifying such material in ethnographical collections.

Pests in Stored Products

THE importance of stored products infestation is to-day widely recognized. The international nature of this problem is demonstrated by a report recently published (Control of Pests in Stored Agricultural Products with Special Reference to Grain. (Project No. 212.) Pp. 169. Paris: European Productivity Agency of the Organization for European Economic Co-operation; London: H.M. Stationery Office, 1958. 700 French francs; 11*s*. 6*d*.; 2 dollars) of a survey the ultimate aim of which was "to ensure that imports of human and animal food arrive in Europe free from active infestation by insects and mites and with the minimum of damage caused by their attacks". The survey lasted eight months and covered North and South America and certain countries in North Africa and the eastern Mediterranean area. It was undertaken by Dr. J. A. Freeman, of the Infestation Control Division of the Ministry of Agriculture, Fisheries and Food, who also wrote the report. He was assisted for part of the time in North America by Dr. Sevelin, of the German Federal Ministry for Food, Agriculture and Forestry. The report is comprehensive, giving factual information concerning the trade practices, pest control organization and the general level of infestation in the countries visited. A large section is devoted to recommendations for future action; these in turn deal with scientific techniques and the furtherance of technical collaboration between different countries, and with the much more difficult and controversial problems posed by certain established practices in international trade. This is perhaps the most valuable feature of the report, in that it clearly points out that the problem of stored food infestation is not one that can be solved by the scientist alone, but requires the active co-operation of the food-handling industry on a fully international basis.

Silicified Permian Fossils from Texas and New Mexico

THE problem of extracting fossils preserved in hard, adherent rock matrix is readily solved when the fossils consist of siliceous pseudomorphs of the hard parts of the original organisms while the matrix remains unaltered limestone. American palæontologists are exceptionally fortunate in the wealth of material available to them preserved in this manner. During the past fifteen years some 60 tons of Permian limestones from the south-western States have been transported to Washington and New York and their fossil contents etched out by the action of hydrochloric acid. Among the vast number of invertebrate fossils thus isolated are remarkably preserved brachiopods, of which G. Arthur Cooper has so far given merely a preliminary account. The gastropods are being described in a series of monographs in the *Bulletin of the American Museum of Natural History*. The first of these, by E. L. Yochelson, was published in 1956 (110; art. 3), while the second (114; art. 2), by Prof. R. L. Batten, who deals with the Pleurotomariacea, has recently appeared (pp. 153–246 + plates 32–42. New York: American Museum of Natural History. 1958. 3 dollars). The state of preservation of the etched-out fossils is such that it has been possible to illustrate the finest details of ornament, while the amount of material is so great that Prof. Batten has been able to make elaborate statistical studies of the various species, probably for the first time in the case of pre-Tertiary gastropods. The work that is being carried out by these American authorities is a most notable contribution to our knowledge of the invertebrate life of Upper Palæozoic seas.

Extraction of Helium from Gas Mixtures

DURING the Fifth International Conference on Low Temperature Physics and Chemistry, held at Madison, Wisconsin, in 1957, concern was expressed because at present only a small proportion of helium is extracted from the considerable volume of helium-rich natural gas that is used as a fuel, so that a large proportion of our limited helium resources is being wasted. There will therefore be considerable interest in a new and simple method of extracting helium that is being developed by K. B. McAfee, of the Bell Telephone Laboratories. The method makes use of the fact that, under a high pressure difference, helium, but not other gases, will diffuse fairly rapidly through a thin wall of silica or 'Pyrex' glass, especially if the glass is at a high temperature. In a practical arrangement, the mixture containing helium is passed around the outside of a large number of glass capillaries of 0·002 in. external diameter and 0·0002 in. wall thickness, and the helium is extracted from inside the capillaries. With a pressure difference of 1,000 atmospheres, a practical cell containing capillaries occupying a volume of about 2 cu. yd. could extract from a 1 per cent mixture about 1,000 cu. ft. of helium per day at room temperature and about 100,000 cu. ft. at 400° C. It is suggested that all the helium-rich natural gas that is collected could easily be passed through such cells. The resulting helium is very pure, and the process could also be used simply for purification.

Indian Society for Plant Physiology

DURING August 1957 plant physiologists from all parts of India met at the University of Delhi to

participate in a seminar on "Modern Developments in Plant Physiology", which was held under the chairmanship of Prof. K. V. Thimann, professor of botany, Harvard University. At the seminar it was decided to constitute an Indian Society for Plant Physiology. The inaugural meeting of the Society was held on January 24 in the University of Allahabad. The constitution of the Society was adopted and the following officers were elected for 1958: *President*, Prof. P. Parija (Utkal University); *Vice-Presidents*, Shri Boshi Sen (Vivekananda Laboratory), Prof. Shri Ranjan (Allahabad University), Dr. J. C. Sengupta (Botanical Survey of India); *Honorary Secretary*, Dr. J. J. Chinoy (University of Delhi); *Honorary Treasurer*, Dr. K. K. Nanda (University of Delhi); *Editor-in-Chief*, Dr. R. D. Asana (Indian Agricultural Research Institute, New Delhi). Prof. K. V. Thimann (Harvard University), Prof. Kurt Mothes (University of Halle) and Prof. F. G. Gregory (Imperial College of Science and Technology, London) were unanimously elected honorary members of the Society. The Society intends to publish a journal called *The Indian Journal of Plant Physiology*.

Challenger Society

A JOINT meeting of the Challenger Society and representatives from marine laboratories will be held at the Scottish Home Department, Marine Laboratory, Aberdeen, on July 1 and 2, when a number of papers will be read and discussed, on various topics in marine biology. Further information may be obtained from Dr. H. Wood, Marine Laboratory, P.O. Box No. 101, Victoria Road, Aberdeen, to whom all applications to attend should be addressed. The Committee of the Challenger Society has received a grant from the Development Commission Fund to assist in paying the expenses of certain oceanographers attending joint meetings arranged by the Society. Applications for grants for the above meeting are invited and should be sent to the Honorary Secretary, Challenger Society, National Institute of Oceanography, Wormley, Godalming, Surrey, before June 20, from whom further particulars are available.

The Challenger Society is prepared to make small grants for research in marine biology or oceanography at a recognized laboratory during the year June 1958–June 1959. Applications, accompanied by details of the proposed research, should reach the Honorary Secretary of the Society not later than June 28.

University News: Birmingham

DR. D. V. HUBBLE, at present consultant physician to the Derbyshire Royal Infirmary, Derby City Hospital and the Derbyshire Hospital for Sick Children, has been appointed to the chair of pædiatrics and child health in the University of Birmingham, made vacant by the retirement of Prof. J. M. Smellie, from October 1. The title of reader in physical metallurgy has been conferred on Dr. R. W. Cahn, senior lecturer in physical metallurgy.

Nottingham

THE following appointments have recently been made in the University of Nottingham: Dr. J. D. Ivins, at present lecturer and acting head of the Department of Agriculture, to be professor of agriculture from September 1; Dr. K. W. H. Stevens, at present reader in theoretical physics, to be professor of theoretical physics; and Dr. F. A. Wells, at present reader in applied economics, to be professor of industrial economics.

Announcements

DR. F. W. WENT, formerly professor of plant physiology at the California Institute of Technology, has been appointed director of the Missouri Botanical Garden, St. Louis, and professor of botany at Washington University, from September 1.

DR. AND MRS. J. B. HERSEY, of the Woods Hole Oceanographic Institution, have been awarded the John A. Fleming Medal, of the American Institute of Geonomy and Natural Resources, "for outstanding accomplishment in science and human welfare". The John A. Fleming Medal, founded in 1955, is awarded annually by the American Institute of Geonomy and Natural Resources. The first award was to Dr. Fleming's daughter, who designed the medal, in 1956, at Washington, D.C. The second award, 1957, was to Dr. and Mrs. William Taylor Thom, jun., at Princeton, New Jersey. The third award is announced above, and the fourth, 1959, will be to Dr. and Mrs. Hugo Boyko, at Rehovot, Israel.

THE following new officers were recently elected by the Physical Society for the year 1958–59: *President*, Mr. J. A. Ratcliffe; *Vice-president* (who has filled the office of President), Prof. N. F. Mott; *Vice-presidents*, Prof. R. W. Ditchburn and Mr. A. J. Philpot; *Honorary Secretary*, Mr. A. G. Peacock; *Honorary Treasurer*, Dr. D. A. Wright.

AN International Symposium on Nuclear Electronics, organized by the Société des Radioélectriciens, will be held in Unesco House, Paris, during September 16–20. Further information can be obtained from Colloque International Électronique Nucléaire, 10 avenue Pierre-Larousse, Malakoff (Seine), France.

THE Textile Institute is organizing a conference on the mechanical properties of textile materials, to be held at Gothenburg, Sweden, during September 4–8. An opportunity will also be afforded for those attending to visit Copenhagen on September 9, when there will be a lecture on quality control at the Federation of Danish Industries and a visit to C. Shous Fabriker A/S. Further details can be obtained from the Textile Institute, 10 Blackfriars Street, Manchester 3.

THE Third Symposium on Atmospheric Condensation Nuclei will be held in the Cavendish Laboratory, Cambridge, during July 16–18. The programme will include four scientific sessions, and it is hoped that the discussions will include the following topics: physics and chemistry of atmospheric aerosols, Aitken nuclei, freezing nuclei, physics of condensation, effect of radioactive fall-out on potential gradient, aspects of atmospheric electricity related to condensation nuclei. Accommodation for men has been reserved in Sidney Sussex College, but ladies, and gentlemen accompanied by their wives, should make arrangements individually to stay in hotels. Offers of papers for the Symposium and requests for further information may be addressed to Dr. T. W. Wormell, Cavendish Laboratory, Cambridge.

ERRATUM. In the communication entitled "A New Transaminase of *Corynebacterium diphtheriae*" by M. Bagdasarian in *Nature* of May 17, p. 1399, the headings on the chromatograms should be interchanged. Spots c are better described as 'markers'.

CHEMICAL ENGINEERING BUILDING OF THE COLLEGE OF SCIENCE AND TECHNOLOGY, MANCHESTER

THE Chemical Engineering Building of the Manchester College of Science and Technology was opened officially on May 19 by Sir Alexander Fleck, chairman of Imperial Chemical Industries, Ltd. Sir Alexander, speaking to an audience of some three hundred guests from industry, referred to the continued demand for chemical engineers and illustrated the growing needs by reference to the development of technology in India and in the U.S.S.R., which he suggested would require that British industries should be maintained at the highest economic level. For this purpose it would obviously be necessary to increase and maintain our output of trained technologists, and he was therefore very happy to see so many industrial guests present at the opening ceremony, for, in the training of technologists, the closest co-operation between industry and the universities was an essential requirement. Sir Hugh Beaver, president of the Federation of British Industries and president of the Institution of Chemical Engineers, in thanking Sir Alexander on behalf of the College and of industry, also congratulated the College authorities on providing a Department which would "surely be for all time the largest single source of chemical engineers in the British Isles". After the opening ceremony the visitors were able to inspect the laboratories and teaching facilities which had been provided in the converted cotton mill.

The main building, including basement, ground-floor and six floors, totals about 120,000 sq. ft. in area and is separated from a five-story block containing floor area of about 32,000 sq. ft. by the main staircase and lift shafts. The smaller area of 32,000 sq. ft. has been used to provide a variety of lecture and seminar rooms. The basement of the main building is used by the Mechanical Engineering

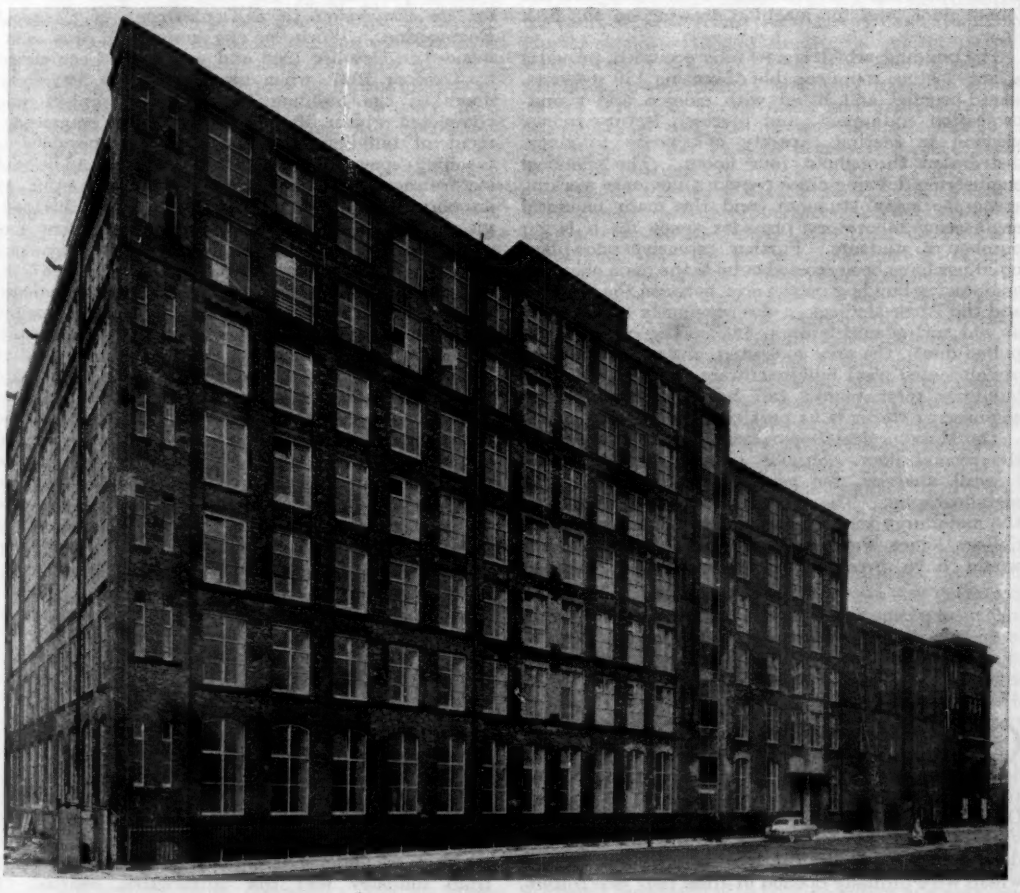


Fig. 1. Chemical Engineering Building, College of Science and Technology, Manchester

Department for the strength of materials and fatigue testing laboratories; but at the northern end a portion of the basement, some 40 ft. deep and 100 ft. long, is used as the bottom story of the chemical engineering laboratory, which extends from the basement through to the ground-floor, thus providing access to chemical engineering pilot plants at two levels. On the ground floor the main lecture theatre and teaching laboratories of the Chemical Engineering Department are placed around a central hall in which facilities for student refreshment are provided. The main chemical engineering laboratory is entered from this hall, and on the ground-floor of the laboratory three large sections have been removed from the floor to form the two-story pits through which extraction columns, distillation columns, evaporators, etc., of the Chemical Engineering Department are built. On the northern wall of the laboratory a gallery has been erected 10 ft. above ground-level to facilitate the operation of these tall units. The first floor contains the design office of the Chemical Engineering Department, together with research laboratories, conference room, library and office facilities for the chemical engineering staff, and lecture rooms. Similar provisions are made on the upper floors, for the teaching of metallurgy and fuel technology on the second floor, for textile chemistry on the third floor, for industrial biochemistry on the fourth floor, and for machine drawing on the fifth floor.

The building, which is now fully occupied, provides a large lecture room capable of seating 130 students, sound-proofed and fitted with cinema and sound-projection equipment, and fourteen lecture rooms, varying in seating capacity of twenty to sixty, distributed throughout four floors. The chemical engineering drawing office provides adequate working space for sixty students, and the main chemical engineering laboratory provides space for a larger number of students. Further extensive pilot-plant buildings have been erected outside the main chemical engineering building on the area between the building and the River Medlock, a site previously occupied by an old cotton mill built in 1850. The old mill was pulled down, the area concreted, and on it two large prefabricated steel buildings were erected. In these buildings pilot plants will be built by chemical engineering students as part of their training.

The Metallurgical Department, which is housed on the second floor, contains laboratories for metallurgical analysis, for general metallurgy and for metallography. The main research laboratories of the metallurgy school remain in the extension of the College, since their removal to the new building would have involved very considerable expense, which at this stage was not considered justified. Fuel technology is housed on the second floor, and in addition to the main teaching laboratories includes a number of research laboratories in which the special apparatus required for the investigation of combustion and the analysis of combustion products is housed.

The Textile Chemistry Laboratories on the fourth floor, in addition to providing laboratories for the study of the chemistry of textiles, also provide physical laboratories for the study of the physical properties of textile materials, microscopic analysis and the study of elastomers and plastics, and a number of smaller laboratories in which the research school of the Department will be housed. The Industrial Biochemistry Department on the fourth floor contains, in addition to two large teaching laboratories, several large research laboratories, a media room, an autoclave room, two constant-temperature rooms and one cold room, and each of the laboratories has an inoculation room. The large drawing office on the fifth floor has provision for three hundred students working at one time, although it is divided into rooms by partitions which split the classes into smaller groups.

The project was commenced in May 1956 when the University Grants Committee gave permission for the purchase of the existing cotton mill and for its conversion to a Department of Chemical Engineering. Work on the conversion was commenced in October 1956 and was in part completed by October 1957, when teaching in the first three floors of the building began. The project was completed within fifteen months of the commencement of building operations and has provided a teaching space of 120,000 sq. ft. and additional lecture rooms and seminar rooms of 32,000 sq. ft. at an approximate cost of £488,000. With this provision the Chemical Engineering Department has expanded from a student intake of twenty-eight students per annum to sixty students in 1957–58, and from 1958–59 it is proposed to accept 120 students per annum. This expansion has been made possible by a corresponding expansion in the teaching staff of the Department, which has grown from a total of six in 1955 to twenty in 1958. The postgraduate research has shown a similar increase, and the visitors to the chemical engineering building were able to see something of the research activities now being carried out in the chemical engineering school. These include studies on mass transfer processes, investigations into the composition of petroleum, studies of corrosion and of the properties of certain protective coatings, the properties of a variety of tower packings and investigations of distillation at reduced pressures.

THE RADIO RESEARCH STATION, SLOUGH

ON May 20, members of the Radio Research Board visited the Radio Research Station, one of the establishments of the Department of Scientific and Industrial Research, to inspect the work in progress. On this and the following day, several hundred visitors were invited to see various exhibits and demonstrations at the Station, the new buildings of which were formally opened in June 1957 (see *Nature*, 180, 163; 1957).

The Radio Research Station conducts an extensive programme of research in the fields of radio-wave propagation and allied subjects for which adequate provision is not made elsewhere in Britain. Advice on the nature and extent of this programme is given to the Department by its Radio Research Board, which is an independent body comprising members from industry and the universities, assisted by assessors from the main Government departments

concerned with the various applications of radio techniques.

A major part of the research programme is designed to assist those responsible for developing and operating radio services in the fields of communications, broadcasting including television, and aids to aerial and marine navigation. The efficient and economical use of the radio-frequency spectrum depends to a major extent on a detailed understanding of the modes of propagation of radio waves at all frequencies and for all conditions of transmission over the ground and through the upper and lower atmosphere. Research is also undertaken on atmospheric noise with the view of minimizing its effect as a source of interference. To assist in the conduct of this work on a world-wide basis, observatories or sub-stations are staffed and maintained at Inverness, Singapore and Port Stanley in the Falkland Islands. Direct co-operative assistance is also provided for similar observatories installed at University College, Ibadan, Nigeria, and at Port Lockroy, Graham Land. Special assistance is being given to the Royal Society's expedition to Halley Bay, Antarctica, for the period of the International Geophysical Year. Radio observations are also being made at Slough and Singapore on transmissions from artificial Earth satellites.

Apart from this extensive study of radio-wave propagation, research is being conducted on certain characteristics of semi-conductors and on ferrites as materials of special interest in the radio industry. The development of techniques for measuring power, field strength and other quantities at very high radio-frequencies is being pursued, and secondary standards set up where appropriate.

Following extensive work in the past in the detailed study of radio direction-finding over a very wide range of frequencies, more attention has been given recently to the phenomena encountered at very low frequencies (10–20 kc./sec.) in special relation to the use of such long waves for radio aids to navigation. The results displayed to visitors at the Station illustrated the changes in phase and amplitude of the waves observed at various distances up to some 8,000 km. from one or other of the few radio transmitting stations operating on such low frequencies.

More extensive studies of the part played by the ionosphere in the propagation of high-frequency radio waves (3 to 30 Mc./s.) to various distances around the world were demonstrated in detail. The ionospheric observatory was engaged in its normal routine of recording the important characteristics of the ionosphere immediately overhead; while various other means were shown of examining the corresponding conditions in the ionosphere at points remote from the observer. In a new technique, demonstrated for the first time, a special transmitter has been set up in Malta which sweeps over the frequency band of 5·5–25 Mc./s. in steps of 20 kc./s., each step lasting 0·4 sec. The receiver at Slough sweeps over the same band, the two sets of equipment being kept in synchronism by very stable crystal clocks. Observations of the signals received under these conditions provide a useful means of studying the ionospheric conditions near the midpoint of the path some 2,000 km. in length. The alternative method of observing the mode of propagation of radio waves over this and greater distances using back-scatter technique was shown in operation; and an interesting cinematograph film entitled "Scatter Sounding—a New Technique for Studying High-Frequency Radio Propagation" was also displayed.

The analogous phenomena accompanying the propagation of very short waves by refraction, reflexion and scattering in the troposphere were demonstrated at frequencies ranging from 30 to 10,000 Mc./s. Some interesting results of the radar sounding of the troposphere at vertical incidence were shown, with photographic records illustrating reflexion from discrete layers at heights up to a few kilometres. A new microwave refractometer has been developed for exploring the meteorological conditions in the troposphere and relating these to the associated radio phenomena.

An impressive demonstration was given of the means now used to investigate the nature and source of those atmospheric disturbances which arise from thunderstorms. One set of apparatus was counting lightning flashes occurring within a short radius, 20 km. or so, from the station; while other equipment observed the direction of more distant sources and measured the frequency of occurrence and amplitudes of the resulting atmospherics. This, like much of the other work in progress at the Radio Research Station, is being conducted on a co-operative basis and forms part of the programme of the International Geophysical Year.

Of very topical interest was the actual reception of radio signals from the latest Russian artificial Earth satellite (1958 δ) during its orbital passage near Great Britain. As in the case of previous satellites, measurements are being made at Slough of the direction, in elevation and azimuth, of the transmissions and also of the Doppler change in frequency as the satellite approaches and recedes from the Station.

Some of the work demonstrated was concerned with a study of the properties of certain materials, semi-conductors and ferrites, now being used in radio technique. The results of measurements on transistors at low and at high radio frequencies were shown, together with some of the properties at microwave frequencies of ferrites of known composition and structure. In a neighbouring laboratory devoted to measurements of a secondary standard type, a new technique for the accurate measurement of power at centimetre wave-lengths was shown, together with the apparatus for measuring field strength and frequency, and used in connexion with the general work of the Station. At a wave-length in the neighbourhood of 3 cm., powers from 0·1 to 100 mW. can be measured with an error which does not exceed 2–3 per cent.

The scientific work of the Radio Research Station is supported by well-equipped workshops, in which many of the specialized instruments are produced, together with the novel aerial systems used. The library also contained a display of the sources of literature used for the abstracts and references published monthly in the *Electronic and Radio Engineer* (London) and the *Proceedings of the Institute of Radio Engineers* (New York). The Station is set in very attractive surroundings. The building, which is functionally designed, is clearly very suitable for its intended purpose; while the surrounding fields of some 200 acres provide adequate space for extensive aerial systems, as well as for the erection of small isolated huts for the conduct of special experiments under conditions free from the interference normally associated with large buildings and populous areas.

NUTRITION AND CLIMATIC STRESS

NUTRITION and environmental physiology are both applied studies, each operating on a particular aspect of and parts of the organism, and each using for its premises the purer sciences of physiology and biochemistry. Having the same bases the two subjects have, therefore, much ground in common. Too frequently that ground is cultivated by the two groups, lacking not so much common interest as common knowledge. Some appreciable step towards breaking down specialist compartmentalism at this particular boundary was made by the symposium on "Nutrition and Climatic Stress" held by the Nutrition Society on April 26 at the Hannah Dairy Research Institute in Ayr.

While research on nutrition is a steady flood and represents a considerable fraction of biological research, work on human environmental physiology has had a hesitant history, often dependent on the impetus lent by wars and rumours of wars, and the grants in aid that go with them. On the other hand, work both on the nutrition and on the responses to environmental stress in farm animals has been steadily progressing in close co-ordination, without benefit of such alarms and excursions. The location of this meeting was particularly well chosen, for work at the Hannah Institute on the nutrition and environmental physiology of cattle has been proceeding for many years. The facilities, techniques and community of interest now assembled there for this work form an impressive example of integrated research. The demonstrations of climatic chambers and respiration calorimeters for cattle formed one of the most important services of the meeting.

Dr. T. Bedford (London School of Hygiene and Tropical Medicine) in his introductory address indicated a problem which recurred in various forms throughout the meeting—the problem of measurement and of scales of measurement. Nearly all the thermal components of climate (air temperature, humidity, wind velocity) can be measured with fair precision; even radiant heat can be measured under some limited conditions. From these measurements, however, no satisfactory index of climate as a physiological environment, even with respect only to its effect on heat dissipation, has so far been devised. This difficulty of scale of measurement recurs in the measurement of physiological response where different functions respond at different temperatures, and any one function responds, in different species, at different temperatures and even in different ways (for example, the heat loss by evaporation in sweating and non-sweating mammals). It recurs yet again in assessment of nutrition, where a scale that takes account of the interaction of environmental temperature and energy exchange may differ markedly from one assessing exchange of protein or other food factors.

H. E. Lewis and J. P. Masterton (Medical Research Council Laboratories) spoke on some aspects of the feeding of field expeditions in cold climates. The primary problem here is that of creating a palatable ration of low weight and bulk and high energy value. A most interesting secondary aspect of this, however, is the problem of food packaging in convenient units and in such a way as to be at the same time resistant to the casual impacts of shipping and handling, and yet yielding without struggle when the time comes actually to get at the food.

The conditions of living of the explorers of the British North Greenland Expedition, 1952–54, as shown in a film and as apparent from some of the published records of the expedition, well illustrate a further point raised by Dr. Bedford, that any consideration of the stress of climate must take into account the indoor as well as the outdoor climate. The effective climate to which the members of this expedition were exposed during the winter months was that of a house maintained at a rather higher temperature (50–70° F.) than that obtaining in the majority of British homes during the same season. It came as little surprise, therefore, to find that the explorers put on weight during this period.

The most obvious interaction of climatic stress and nutrition is in the field of energy exchange. It is, indeed, only this aspect of the subject on which any considerable body of data is available. Perhaps because of this it is also the field in which some major disagreements and discrepancies are apparent. R. E. Johnson and F. Sargent (University of Illinois) described in outline the results of a marathon study on U.S. Air Force personnel in hot-humid, temperate and cold environments, covering 8,696 man-days. This work involved, as variables, climate, food intake, food composition, water intake, and work. Since some of their data on imposed stress and physiological response were entirely qualitative and much was largely qualitative, the interpretation of this large mass of information is a difficult and equivocal business. Apart from the inter-relations which might be expected from well-known physiological principles, they found that water-balance under any given set of conditions was a maximum at a particular osmotic load, and declined on either side of it. They also found that low temperatures or a high fat diet without a high imposed work load can produce a degree of ketosis which is directly related to the percentage of fat in the diet and inversely related to the temperature.

Johnson and Sargent interpreted their energy data to mean that at a low temperature there is little difference from thermal neutrality in the partition of energy usage from protein, fat and carbohydrate. They also tried to explain some of their findings on nitrogen-balance and intake of energy on the basis of the specific dynamic action of the various rations and the energy available for muscular work at various temperatures.

K. L. Blaxter (Hannah Institute) presented data to show that, at low temperatures, the cow derives almost all its excess heat production from metabolism of fat. He also demonstrated that below the critical temperature, with respect to energy exchange (namely, thermal neutrality), the heat increment of feeding becomes inseparable from general heat production. In addition, however, he pointed out that the critical temperature varies with the level of feeding, falling, in some animals, even to 0° C. or below. The critical environmental temperature also, of course, varies with heat insulation, and in man that includes clothing. While, therefore, many of these discrepancies may lie in the lack of

comparability of experimental conditions and subjects, the fact that such discrepancies can exist in the only reasonably well-documented part of the subject illustrates how little has yet been done.

The great differences in response to climatic stress between a sweating and a nearly non-sweating mammal were made very plain by J. D. Findlay (Hannah). In a dry atmosphere, increase in environmental temperature well above normal deep-body temperature in man can be tolerated by great increases in rate of sweating and elimination of heat by evaporation (the classical experiment proved survival at 127° C.). The cow has a type of poorly vascularized sweat gland, but approaches its sweating maximum at about 26° C., above which loss of heat by panting is substituted. Panting in turn reaches its maximum effectiveness at about 40° C., which is an almost lethal temperature.

Information on other aspects of interaction of climatic stress and nutrition is sparse. Discussion by R. H. Fox (Medical Research Council Laboratories) and by Blaxter and others on the changes in requirement for vitamins, and on losses of amino-acids and minerals through the skin, and the relation of these to such deficiency-diseases as pellagra and kwashiorkor were speculative.

S. D. Morrison

X-RAY RESEARCH

THE Spring Conference of the X-ray Analysis Group of the Institute of Physics was held in the College of Science and Technology, Manchester, on April 18 and 19. No particular subject was fixed for discussion, and papers were invited on any topic in the field of crystallography and X-ray analysis.

A novel feature of the Conference was a part-session devoted to the reading of five papers by research students. Although there have, of course, been papers at previous conferences of which research students have been authors or joint authors, the Group committee felt that to set aside a period for such papers might particularly encourage research students to feel that their work was of value and worthy of the attention of the Group as a whole. The five papers discussed were selected from some ten papers offered.

Mr. J. V. P. Long (Cavendish Laboratory, Cambridge) described experiments on the use of fine-focus X-ray tubes and X-ray absorption and emission spectra for quantitative micro-analysis. Although some information can occasionally be obtained from absorption measurements by using one X-ray wavelength alone, such measurements are more fruitful if two wave-lengths are employed lying on each side of an absorption edge of the element of interest. An apparatus developed for such measurements makes use of an X-ray focal spot about 1μ in diameter and a crystal monochromator with a proportional counter as detector of the transmitted radiation. It has been used for the determination of calcium in rock sections and in biological materials. Emission spectroscopy, with a somewhat similar apparatus except that the monochromator is now placed out of the primary X-ray beam, has also been used for determination of calcium in these specimens; it seems likely to be more sensitive to small amounts of a given element than the absorption technique, but to be less well fitted to provide accurate information about the distribution of the element in a thin section.

The remaining four papers were concerned with structural investigations. Mr. R. Maitland (King's College, Newcastle upon Tyne) dealt with the crystal structures of chromous and chromic fluorides. The trifluoride structure was determined with little difficulty from powder photographs; it is rhombohedral and of the vanadium trifluoride type, with regular CrF_6 octahedra. In chromium difluoride, however, the symmetry is only monoclinic, and the CrF_6 octahedra are distorted, giving three different chromium–fluorine bond-lengths; the structure may be regarded as a distortion of a rutile-type structure. The differences in bonding between the two fluorides can be completely accounted for by ligand field theory.

Mr. S. Hosoya (University College, Cardiff) discussed the structures of two isomers of thianthrene dioxide, which are of interest as examples of sulphoxides, about which there has been much recent controversy. Only two isomers of thianthrene dioxide have been found; the α-isomer, which has the higher melting point and smaller dipole moment of the two, has been shown by two-dimensional X-ray studies to have the *anti-cis* form as predicted by Taylor[1] and the β-isomer to have the *trans* form. Three-dimensional studies of both isomers are in progress to provide detailed information about the sulphur bonding and the folding of the molecules for comparison with other sulphoxides.

Mr. R. Hino (University College, Cardiff) described a determination of the crystal structure of (+) S-methyl-L-cysteine-S-oxide. This substance crystallizes as colourless orthorhombic laths; the space group is $P2_12_12_1$, with $a = 5{\cdot}2$, $b = 7{\cdot}4$, $c = 16{\cdot}3$ A., and the molecular arrangement consists of pairs of sheets parallel to (001) with an elaborate arrangement of short non-bonded distances between certain atoms of the molecules in each sheet. The structure contains an optically active carbon of known configuration, and thus the determination is, in effect, one of the absolute configuration of an asymmetric sulphur atom. The structure of the (−) S-isomer is now being investigated to provide further information about the S—O bond.

Mr. H. C. Watson (College of Science and Technology, Manchester) had made use of the optical transform techniques developed in the Physics Department of the College in determining the structure of β-naphthol from X-ray data. The space group of the crystal is *Ia*, and the unit cell has $a = 8{\cdot}185$, $b = 5{\cdot}950$, $c = 36{\cdot}29$ A., with $\beta = 119°\ 52'$. Projections parallel to the 100 and to the 010 axis were calculated independently; these two projections left a choice between only two possible structures, the projections parallel to 100 and 010 of which were identical but different parallel to 001. The choice between them was made on the basis of intermolecular distances, an oxygen–oxygen distance of 1·8 A. in one structure being rejected in favour of 2·7 A. in the other, and verified by examining the intensities of a number of general reflexions *hkl* in an oscillation photograph about the *b*-axis.

R. L. Gordon

[1] Taylor, T. W. J., *J. Chem. Soc.*, 625 (1935).

FUTURE OF THE AIRCRAFT INDUSTRY IN BRITAIN

IN a statement regarding the Government's future policy for research and development in the aircraft industry made in the House of Commons on May 13, the Minister of Supply, Mr. Aubrey Jones, said that, like the aircraft industries of other countries, the British industry has from its early days been supported by work done in Government establishments in connexion with defence and has developed with the help of Government contracts for research, development and production. Although the current reduction in defence demands will inevitably entail some contraction in the size of the industry, the Government will continue, as necessary, to sponsor and finance aeronautical research and development to meet defence requirements for aircraft and guided weapons. The industry has also been making a valuable contribution to the general economy of the country and to technological progress, and it has received material help from research undertaken under Government auspices primarily for defence purposes. So long as the achievements of the industry justify the expenditure, the Government intends to continue to make a financial contribution to aeronautical research in the field of civil transport, where this is not already covered by defence research.

The Government expects that the industry will progressively assume financial liability for this research, but considers it is also necessary for the industry to reorganize itself to meet the changed conditions and ensure that, in general, the industry is able increasingly to finance the development of new civil projects without Government assistance. The Government will, however, be prepared to consider individual applications for development assistance on their merits. Amplifying this, Mr. Jones said that research is being undertaken into the possibility of a supersonic civil transport, and if the research develops to a point where an aircraft manufacturer begins to develop a selected design, the Government will consider, in the light of circumstances then obtaining, the possibility of a Government contribution.

The Royal Aircraft Establishment at Farnborough will continue research for military and civil aircraft, both manned and unmanned, and into subsonic as well as supersonic flight. The broad intention is to continue aeronautical research on about the present scale, and Mr. Jones emphasized that the demand for military aircraft is subsiding, but that hitherto military and civil research has been conducted as a whole. As civil research becomes more and more identifiable, the cost of that research will in course of time be passed on to the industry, although the research may still be conducted in a Government establishment. There are no grants to specific firms; the practice has been to contribute to the development of a civil aircraft and thereafter to exact a levy on the sales of that aircraft. Investment in normal aircraft on the part of the Government will cease, but when it comes to future aircraft embodying a great technological advance, the Government will consider the possibility of some help in the light of the particular circumstances.

THE ROYAL AERONAUTICAL SOCIETY

AWARDS FOR 1957–58

THE following awards have been made by the Royal Aeronautical Society: Honorary Fellowship to Sir Richard Southwell and Honorary Companionship to Mr. W. E. Nixon; *The Society's Gold Medal* (the highest honour the Society can confer) to Sir Sydney Camm, director and chief designer, Hawker Aircraft, Ltd., for his outstanding achievements in aircraft design and development; *The Society's Silver Medal* to Dr. P. B. Walker, Air-worthiness Department, Royal Aircraft Establishment, Farnborough, for his distinguished contributions to aircraft structural integrity; *The Society's Bronze Medal* to Dr. D. Williams, for his contributions to the theory of aeroelasticity; *The British Gold Medal for Aeronautics*, to Mr. S. D. Davies, managing director, Dowty Fuel Systems, Ltd., for his outstanding practical work in the design and development of delta-winged aircraft; *The British Silver Medal for Aeronautics* to Mr. W. H. Lindsey and Mr. W. F. Saxton, both of Armstrong Siddeley Motors, Ltd., for their practical contributions to the development of aircraft gas turbines; *The Wakefield Gold Medal* to Mr. W. Tye, chief technical officer, Air Registration Board, for his great contribution to the air-worthiness of British civil aircraft; *The R. P. Alston Medal* to Mrs. Anne Burns, Structures Department, Royal Aircraft Establishment, Farnborough, for her practical contributions to aircraft safety as a flight test observer; *The N. E. Rowe Medal* to Mr. P. A. Champion, of Bristol Aircraft, Ltd., for his paper on the design of supersonic wind tunnels; *The Simms Gold Medal* to Mr. L. F. Nicholson, head of the Aerodynamics Department at the Royal Aircraft Establishment, Farnborough, for his paper on engine–airframe integration; *The George Taylor (Australia) Gold Medal* to Mr. R. L. Lickley and Mr. L. P. Twiss for their paper, "The Fairey Delta 2" (Mr. Lickley, formerly professor of aircraft design at the College of Aeronautics, Cranfield, is now technical director of the Fairey Aviation Company, Ltd. Mr. Twiss is chief test pilot of the Fairey Aviation Company, Ltd., and was the holder, during March 1956–December 1957, of the world speed record of 1,132 m.p.h. in the Fairey Delta 2); *The Edward Busk Memorial Prize* to Dr. D. Kuchemann, a senior principal scientific officer at the Royal Aircraft Establishment, Farnborough, for his paper on methods of reducing the transonic drag of swept-back wings at zero lift; *The Orville Wright Prize* to Prof. A. R. Collar, professor of aeronautical engineering in the University of Bristol, for his paper, "On the Stability of Accelerated Motion—Some Thoughts on Linear Differential

Equations with Variable Coefficients", published in *The Aeronautical Quarterly*; *The Herbert Ackroyd Stuart Memorial Prize* to Dr. R. R. Jamison, assistant chief engineer in charge of ram jets at the Bristol Aero-Engine Company, Ltd., for his paper on ram-jets; *The J. E. Hodgson Prize* to Prof. H. J. van der Maas, professor of aeronautical science in the University of Delft, for his paper on aeronautical research in the Netherlands; *The Branch Prize* for 1958 has been awarded for the Roy Chadwick Memorial Lecture, read before the Manchester Branch in May 1957 by Mr. M. B. Morgan, one of the two deputy directors of the Royal Aircraft Establishment, Farnborough, on "Some Thoughts on Aeronautical Research and Design"; *The Navigation Prize* to Mr. W. Makinson and Mr. G. M. Hellings for their paper on synthetic aids to flying training (Mr. Makinson is managing director and Mr. Hellings is chief engineer of Air Trainers Link, Ltd.); *The Usborne Memorial Prize* to Mr. D. G. Drake, lecturer in the Department of Aeronautical Engineering at the University of Southampton, for his paper, "The Oscillating Two-Dimensional Aerofoil between Porous Walls", published in *The Aeronautical Quarterly*. Sir Arnold Hall, director of the Hawker-Siddeley Group, took office as president of the Royal Aeronautical Society at the conclusion of its annual general meeting on May 8, in succession to Sir George Edwards, managing director of Vickers-Armstrongs (Aircraft), Ltd.

THE NATURE CONSERVANCY

THE eighth annual report of the Nature Conservancy* covers the year ended September 30, 1957; and the shift in emphasis in the work of the Conservancy towards the execution of its research programme, the application of ecological and other acquired or currently emerging knowledge and the improvement of its educational and other advisory services noted in the previous report was maintained. The year's experience gives further point to the hope expressed in the concluding words of that report that the Conservancy's findings would demonstrate that, where the land is concerned, long views are sound views. The need for the Conservancy has been repeatedly demonstrated during the year, and effective backing has still to be won for a comprehensive long-term approach in which, in the light of expanding scientific knowledge, the conservation of the natural resources of plant and animal life in Britain can be blended with tradition and with economic and other national considerations in policies of land use and land management. The Nature Conservancy has sometimes been pressed to fall in with particular current attitudes and practices which it has reason to believe to be unsound, and it should be assured of the support of all scientists in refusing to trim its scientific findings and management plans to satisfy sectional and opportunist views. As the report rightly concludes, conservation is for all time, and should not be continually subordinated to issues of expediency which hold only for a decade or two or even less.

The report shows that there are need and opportunity for much more clearly expressed support of the work of the Conservancy by scientists in general, and by all those who care for the ideas which the Conservancy represents. Close liaison with the Central Electricity Authority has enabled the Conservancy to avert several collisions, and the nuclear power programme has gone ahead without delay, and so far with a minimum of damage to the fauna and flora and to important physiographical features; although the pace of current development of agriculture, forests, highways, airfields, defence installations, nuclear power stations, extraction of minerals, oil refineries and pipelines has necessitated many hasty decisions involving irreversible consequences for the land and its natural resources of soil, water and animal and plant life. The liaison established on St. Kilda has minimized and not eliminated damage from developments necessitated by the Hebridean Guided Missiles project and no more can be claimed or expected from the consultations over developments at Milford Haven.

It is the more urgent and important accordingly to accelerate the basic and applied research programmes, the result of which may determine the choice between wise decisions giving satisfactory long-term results, and ill-judged decisions which our descendants, if not ourselves, may have cause to regret. While the grant-in-aid for the current financial year (1957–58) has again been increased, practically all this £30,000 will be absorbed by the effects of inflation, and the resources devoted to research are not yet in any way commensurate with their importance or with the scale of economic and other losses which may result from continuing to settle such matters largely in the dark. Of the total grant-in-aid for 1956–57 of £280,000, £54,000 was in respect of capital expenditure, and the Conservancy is still unable to meet adequately the expenditure needed for the proper maintenance and management of nature reserves or to make new research grants, although six were extended and ten postgraduate research studentships awarded and sixteen continued.

Besides this, the Conservancy urges that there is still too little appreciation of the damage being done, even to the national nature reserves, by visitors who ignore the importance of safeguarding the bare minimum of strongholds in which the hard-pressed fauna and flora can survive as a permanent part of the national heritage. The need for undisturbed experimental areas where the scientific programme can be carried out without interruption or disturbance is even less widely recognized. Further, there is no national body of citizens who recognize their responsibility to guide, stimulate and educate opinion on the importance of nature reserves.

During 1956–57, the acreage of national nature reserves rose by the acquisition of nine new reserves from 82,662 to 121,825, including the Hebridean islands of Rhum and St. Kilda. Encouraging progress was made by the newly organized Conservation Branch in preparing detailed management plans for nature reserves and in reorganizing the warden

* Report of the Nature Conservancy for the year ended 30th September 1957. Pp. v+99+13 plates. (London: H.M. Stationery Office, 1957.) 5s. net.

service; a new grade of warden/naturalist has been created to reinforce the scientists at headquarters or research stations by trained men permanently in the field. The Conservation Branch is also adding systematic research in applied ecology and reserve management under the regional officers to the existing research programme in ecology and physiography, thus assisting research workers to share the stimulus and responsibility of solving actual land management problems.

The section describing scientific research carried out by the Conservancy now occupies 18 pages out of the 78 pages of the report, together with a 3-page list of sixty scientific publications, while the account of the scientific advisory services occupies a further 14 pages. Investigations of moorland fauna at the Moor House Nature Reserve continued, and a study of methods available for the quantitative estimation of enchytraeid worms indicates that this group plays an important part in the biological turnover of moorland soils. Research work in the Snowdonia area on the influence of local variations in climate on the development and properties of its soils and vegetation, the contemporary productivity and the patterns and process of human settlement, is confirming that the macro-nutrient content of soils at high rainfalls is markedly less than at rainfalls below 100 in. mean annual, but the tendency to develop podsolic profiles is not great. Contrary to expectation, it appears that soils which are developed at rainfalls greater than 150 in. have a lower organic matter content than those developed at rainfalls less than 100 in. mean annual. Preliminary work on the micro- or trace-element content of Snowdonian soils indicates that soils derived from acidic rhyolitic rocks contain much less cobalt than those derived from basic volcanic ashes and dolerites. The weekly study of a chain of sixty-five plots across Snowdonia revealed a marked variation in selectivity of sheep grazing determined by season and weather.

A procedure by which direct sowing methods may possibly be used in place of planting as a means of regenerating native pine stands has been worked out at Beinn Eighe, and the initial phase of the investigation into methods of tree and shrub establishment by direct sowing has been completed. Research on the germination and survival of oak seedlings at the woodland nature reserves of Roudsea and Yarner continued, and at the former small mammals seem to be the primary cause of lack of natural regeneration. Preliminary work with radioisotopes to study nutrient uptake by trees has been carried out in co-operation with scientists from Harwell. Parallel with studies on the successional loss of dry weight in the litter layers of two types of forest humus, intensive investigation of changes in the nitrogen content of oak and ash litter disappearing under field conditions has revealed striking differences between litter from the same source on mull and mor sites. Other work at Merlewood is concerned with the fungi of soil and litter. It has been found possible to transmit ultrasonic energy through fresh samples of oak, birch and pine approximating to healthy and living timber, and that transmission through wood is considerably reduced by slight flaws. Work at Furzebrook on ant populations involved alteration of the climate near the ground and use of radioactive phosphorus to measure populations. Another study was concerned with the factors which limit populations of adult dragonflies.

Surveys of myxomatosis in 1957 were concentrated on a more limited number of sites, in order to assess so far as possible the dangers in rabbit numbers in conjunction with botanical transect work. In coastal research, the most important and intensive work was that at Orfordness with pebbles marked with radioactive tracers and designed to yield information on movement of beach material, both longshore and on the sea bed, carried out with the Isotope Division of the Atomic Energy Research Establishment at Harwell during January–March, and notable for two changes in technique. The chief feature of climatological work during the year was the development of evaporation studies designed as a contribution to knowledge of the relation of water to land use and particularly of natural vegetation cover. Much has already been learned from the observations of potential evaporation at Anancaun (Beinn Eighe Reserve), Achnagoichan (Cairngorms Reserve), Moor House and Crug-las (Cors Tregaron Reserve), and on behalf of the Conservancy at Prabost, Isle of Skye and Lossiemouth. Besides the Scottish vegetation survey, in which about 700 vegetation analyses have been made and classified over the past three seasons, a reconnaissance survey was made of the soils and vegetation of Rhum.

The Nature Conservancy has notified local planning authorities of sixteen sites on canals and reservoirs selected for conservation because of outstanding scientific value, and in February 1957 it submitted evidence to the Departmental Committee of Inquiry into Inland Waterways. The recommendations of the Conservancy for continuance of research and observations on seals as at present, together with an attempt, sponsored by the Scottish Home Department, to discover means of protecting nets against seals, and, as an experimental and interim measure, limitation of further increases in the grey seal by an annual cull of 300 calves if authorized by the Minister of Agriculture, Fisheries and Food, were used as a basis for discussion with the parties concerned. The present position of the use of toxic chemicals in agriculture and food shortage was thoroughly reviewed at a meeting at the Nature Conservancy on September 26, when it was agreed that the two main lines of action should be to arrange with industry for research tests on selected species of birds, insects and fishes during the development of a product, and for field-observations on the effects of the use of the chemicals to be organized with the industry and societies interested.

Research on moor burning in the highland zone has hitherto been concerned largely with the most efficient ways of burning to provide heather in its nutritious stages while allowing it to regenerate quickly from root stocks. Recently, investigations have indicated that the long-term effects of moor burning, even under proper control and on a recognized system, may damage the productivity of the land; this work, carried out in the Moor House Nature Reserve and elsewhere, is to be followed up by more research, since clear evidence is essential if the present system of extractive pastoralism over considerable areas is against the national interest. The scourge of fires on heaths and commons appears to be increasing, and several practical suggestions emerged as a result of a conference called by the Nature Conservancy in February 1957. The biological effects of burning heaths are being studied at Hartland Moor and Morden Bog Nature Reserves. The red grouse investigation, supported by the

Scottish Landowners' Federation, continued principally in Glenesk, Angus, but to a subsidiary extent on half a dozen other moors. The Conservancy has also joined with other interested parties in Scotland in preparing a scientific and humane scheme for the control of red deer which should clear the way to remedy conditions which are a national reproach.

In dealing with the acquisition and declaration of nature reserves, the report refers in some detail to the Isle of Rhum and to St. Kilda, and reproduces the public statement relating to public access to Rhum issued in July. A primary purpose of acquisition is scientific research, and this is one of the few suitable areas in the Highlands where such research can be undertaken without interference with existing uses. The programme contemplated includes controlled experiments on the effects of burning and vegetation recovery, on run-off of water, on the diet and habits of red deer and particularly on the possibilities of restoring tree cover and planting shelter belts. It thus aims at the balanced long-term development of the natural resources of the island for scientific research and training, nature conservation and meat production. The reference to St. Kilda is of particular interest as showing how, given goodwill and a determination to help both sides, a major Services operation on ethnological and wild-life research can proceed in perfect harmony.

During the year the arrears of notification of owners of areas of special scientific interest were finally eliminated in England, but in Wales even greater difficulties have been experienced in tracing the owners of some sites. In the seven years since the surveys were made on which the scheduling of the first English sites was based, conditions have in some instances changed, and at present no habitat type seems more threatened than Chalk grassland, where a re-assessment is urgently needed to protect the best remaining areas which are the refuge of many rare or local species of plants, insects and molluscs. The Conservancy has been obliged to press the strongest opposition to the project of the Tees Valley Water Board for reservoirs in Upper Teesdale, which cannot be reconciled with the conservation of an area characterized not only by the wealth of rare plants but also by an assemblage of species representing a wide range of geographical elements and their importance in post-glacial vegetation studies.

The present state of public knowledge of, and response to, the Protection of Birds Act, 1954, is still inadequate to fulfil the intentions of the Act; and the Nature Conservancy, in co-operation with the Royal Society for the Protection of Birds, has sought to give publicity of the provisions of the Act as well as to check unwise publicity about rare birds. The licensing system regarding the killing of wild birds appears to work smoothly, and in February 1957 the Conservancy held a small exploratory meeting of scientists immediately concerned with the diurnal birds of prey to discuss the present state of knowledge generally, whether any interrelation between predators and food is discernible and what is known of the biological role of birds of prey.

EVOLUTION AND THE COMMON MAN

PRIOR to a recent television series on evolution, the producer asked the Audience Research Department of the B.B.C. to equip him with information about the knowledgeability of potential viewers, their attitude towards evolution and, in particular, how far they believe there to be any conflict between the theory of evolution and other ways of looking at the origin of life, such as that set out in the Old Testament.

Of the 240 London viewers who took part in a series of discussions which were arranged at Broadcasting House, nearly half thought that evolution was connected with 'change', 'progress' or 'development', and half of these specified the process of change in physical things, in life, mankind or species. One in ten made a point of the gradualness of the changes involved. Slightly more mentioned that evolution was concerned with 'the origin of things', though this was not always with living matter or species or man. A third of the sample were unable to volunteer any statement at all.

Viewers were asked whom they associated with evolution. One in three could give no name; the name given by far the most (by one-third of the total) was that of Darwin. A few mentioned Huxley—but as many named Einstein. Other suggestions ranged from Aristotle to Attenborough, or Marconi to Mortimer Wheeler.

The groups were then given the names of a few selected persons whom they might rightly associate with the theory of evolution (Darwin, Huxley, Wallace and Mendel) and they were then asked how these people got their ideas and what they did. About half the viewers were unable to venture any answer to this question. Of those who could, a fifth gave the title of one of Darwin's books, if not always accurately. An equal number said that "they came out with a theory"; and most of these identified the theory as indicating that "man is descended from monkeys", a few giving a more cautious and accurate version. Rather more than one in ten mentioned that the people who worked on evolution study the evidence; and half the viewers referred to specific evidence such as skulls or fossils or rocks. Most of the rest mentioned "studying life generally", "travelling far and wide", "*The Beagle*" or "studying other writings on the subject" as the source of ideas.

Viewers were asked how they thought 'the leaders', the people in important positions, felt about evolution. Those who replied fell into four roughly equal groups. One thought the idea of evolution to be generally accepted by 'the experts', the second thought that 'the leaders' were unconcerned about the subject, the third that they were of quite divided opinions, and the remaining group referred to disagreement between church leaders and others or the attempt to reconcile the religious view with the scientific view.

About two-thirds of the sample of viewers said they themselves believed in evolution; just over a tenth disbelieved the theory, the remainder having no firm opinions. Of those who said they believed in evolution, almost half were unable to advance a reason for doing so. More than a fifth said no more than that it was the "most tenable theory", but almost as many referred to the study of animals, the extinction of

some species and their change in form as being the major reason for their belief. Rock or fossil evidence, or the study of skeletons and remains was mentioned much less often.

Of those who disbelieved in the theory, about half gave their belief in God as the prime reason. Other reasons put forward by very small minorities of the total sample were "because believing in the religious view is the best thing", "because I am a Roman Catholic", or "because I just don't believe it".

Asked what would ultimately happen to man, almost half the viewers were not prepared to volunteer any answer. The replies of those who did were diffuse. In descending order of frequency the forecasts were: (1) that man would suffer destruction at his own hands; (2) that he would increase his power and conquer space; (3) that there would be development of brain power, or that man would lose certain parts, such as his toes. A few thought man to be "at his peak" and not likely to change further.

CHEMICALS DISSOLVED IN RAIN WATER

THE study of the nature of the chemicals dissolved in rain water is important to the agriculturalist and botanist because of their effect in the nutrition of plants and to the meteorologist for the light thrown on the physics of rain formation and on atmospheric diffusion.

Much work has been done on this matter in Sweden in recent years. There it has been found that very near the coast the predominant elements are sodium and chlorine in nearly the same ratio as in sea water (sodium/chloride ratio 0·85) but that inland the proportion of sodium increases rapidly. No satisfactory reason for this increase inland has been put forward.

Mr. E. Gorham, of the Freshwater Biological Association, Ambleside, Westmorland, has recently published* similar analyses of precipitation falling at a point on Hawkshead Moor during January 1955–January 1956.

He found a close correlation between the amounts of sodium and chlorine, with a ratio of sodium to chloride almost the same as that in sea water, and also a close connexion between the amounts of hydrogen, potassium, calcium, nitrate and sulphate ions. There was a remarkably clear association between the chemical constitution of the solutes and wind direction. Rain falling with south-westerly winds contained much more chloride than that with winds from other directions, and similarly, rain with south-easterly winds contained much higher amounts of sulphate and nitrate. The latter effect is naturally attributed to atmospheric pollution from the industrial areas to the south-east of the site. Comparison of hydrogen-ion concentration and sulphate plus nitrate concentration shows that hydrogen and sulphate are largely combined as sulphuric acid. The ratio of sodium to chloride did not, however, vary with wind direction in the way that would have been expected from the Swedish observations. The amounts of both chloride and sulphate plus nitrate increased with wind speed, the observed variation being a ten-fold increase for the first and two-fold for the second. This supports the sea-spray theory of the principal source of atmospheric chloride and agrees with observations at Hawaii.

A further result is that rain, in which the ratio of sodium to chloride was less than 0·8, fell predominantly with easterly winds containing a high proportion of sulphate. This suggested that some chloride is supplied by atmospheric pollution, and a study of the chloride in smoke solids collected by filters in London buildings is found to support this theory. The opposite phenomenon of excess sodium values, the criterion being a sodium chloride ratio of 0·95, occurred in small showers, the highest value of excess sodium occurring in a hail shower. It was first thought that the excess sodium might be produced in these showers by local rock dust, but analysis of lake waters which might equally be expected to show the same effect did not support the hypothesis. Taking the hint from the hail shower, the author then carried out an experiment to see if chemical reaction between sulphuric acid and sodium chloride leading to production of gaseous hydrochloric acid were facilitated by freezing. This was found to be the case, and he suggests that it is possible that excess sodium occurs because the increase in concentration of the solutes brought about by freezing leads to production and subsequent escape of hydrochloric acid.

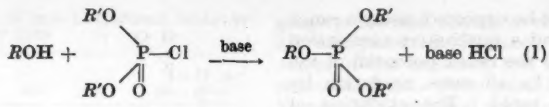
* *Philosophical Transactions of the Royal Society of London.* Series B: Biological Sciences. No. 679, Vol. 241 (9 January, 1958): The Influence and Importance of Daily Weather Conditions in the Supply of Chloride, Sulphate and other Ions to Fresh Waters from Atmospheric Precipitation. By E. Gorham. Pp. 147–178. (London: Royal Society, 1958.) 10*s*.

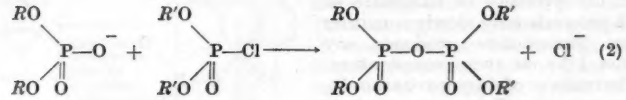
OXIDATIVE PHOSPHORYLATION: A CHEMICAL APPROACH USING QUINOL PHOSPHATES

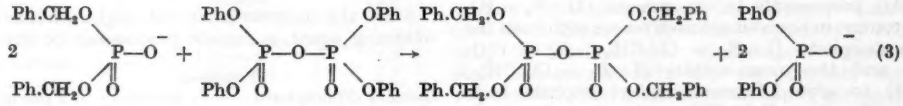
By Dr. V. M. CLARK, G. W. KIRBY and SIR ALEXANDER TODD, F.R.S.
University Chemical Laboratory, Cambridge

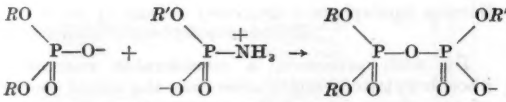
THE ubiquitous occurrence of phosphate and polyphosphate esters in biological systems has, in recent years, stimulated widespread interest in problems of chemical phosphorylation[1]. For the solution of such problems, the phosphorus atom of the phosphorylating agent must be the centre for nucleophilic attack[2], and with the common reagents, for example, the phosphorochloridates[3] and pyrophosphates[4], acylation proceeds with the expulsion of an anion (reactions 1, 2, 3).

The phosphoramidates, another type of reagent, require to be in the zwitterionic form to exhibit their acylating function, the expelled group then being a neutral amine molecule (reaction 4).

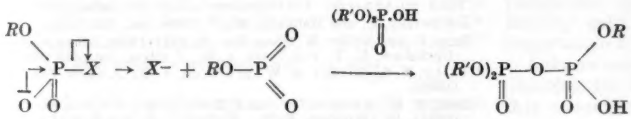




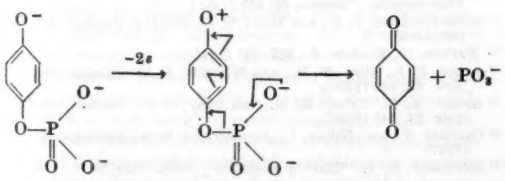




By using this method, adenosine diphosphate has been converted to the triphosphate in high yield[6]. In this reaction, the expulsion of the amine may precede rather than accompany acylation: the intermediate would then be a monomeric metaphosphate which would rapidly phosphorylate an appropriate substrate[6,7].



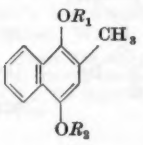
In theory, the heterolysis of the P—*X* bond necessary in order that $(RO)_2P(O)X$ may act as a phosphorylating agent could be achieved by removing electrons from the group *X*, that is, by oxidation. In the case of quinol monophosphate, the following process can be envisaged (cf. refs. 8, 9):



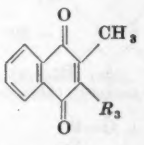
and we now present experimental evidence in support of this scheme.

1-Hydroxy-2-methyl naphthyl-4-phosphate {I: $R_1 = H$; $R_2 = P(O)(OH)_2$} in aqueous solution at *p*H 6·8 in the presence of air is slowly hydrolysed with liberation of inorganic phosphate, the half-life being approximately four days; however, in air-free solution no appreciable decomposition occurs during one week. In alkaline solution, rapid autoxidation greatly complicates further investigation.

The corresponding diphosphate, *Synkavit* {I: $R_1 = R_2 = P(O)(OH)_2$}, which is very stable to hydrolysis (after 6 hr. at 80° C. at *p*H 5, approximately 20 per cent of the phosphate is hydrolysed; personal communication from Dr. K. J. M. Andrews, Roche Products, Ltd.), is rapidly decomposed in aqueous solution by a variety of oxidizing agents. Ceric sulphate in 3 *N* sulphuric acid brings about *immediate* and quantitative[10] oxidation to the quinone {II: $R_2 = H$} as does bromine in aqueous solution, 1 mole of halogen being used without incorporation into the aromatic nucleus. Since synkavit is very resistant to hydrolysis, the dephosphorylation must accompany and not precede the oxidation. Metabolic studies of synkavit carried out in view of its potent inhibition of mitosis of cultures of chick heart fibroblasts[11] and its radiosensitizing action[12] have indicated a rapid dephosphorylation[13] and this, too, could be oxidative in type.



(I)



(II)

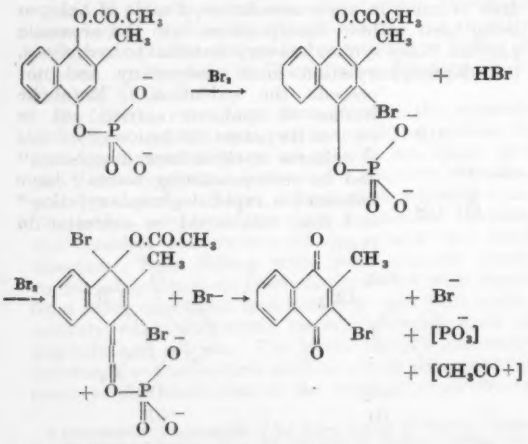
The bromine oxidation of synkavit to the corresponding quinone can be carried out in aqueous solution over a wide *p*H range, the metaphosphate concurrently produced being solvated to orthophosphate. Notwithstanding the water present, bromine oxidation in the presence of orthophosphate leads to the formation of some inorganic pyrophosphate concurrent with quinone precipitation, that is, orthophosphate is phosphorylated to pyrophosphate in consequence of an oxidation. It is noteworthy that the oxidation of dihydro-vitamin K_2 {I: $R_1 = R_2 = H$} by mitochondria is accompanied by phosphorylation[14], and, moreover, a role associated with phosphorylative reactions has been suggested for vitamin K in studies on animal tissue[15], bacteria[16], and chloroplasts[17].

We have carried out analogous oxidations of quinol diphosphates to quinones using derivatives of naphtho-1:4-hydroquinone, 2:3 dimethyl naphtho-1:4-hydroquinone, 2:3:5 trimethyl quinol, 2:3:5:6 tetramethyl quinol and quinol itself, in each case using bromine in aqueous solution as the

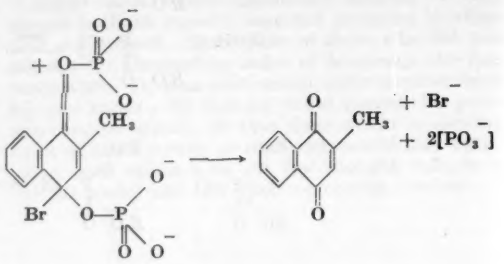
oxidizing agent. As might be expected, using a range of oxidizing agents we find a qualitative correlation between their efficacy and the redox potential of the quinone–quinol system. In all cases, oxidation by ceric ion or bromine is rapid. The oxidation of synkavit with dichromate in acid solution, with hydrogen peroxide in the presence of tungstate or with dilute nitric acid proceeds only slowly: neither iodine nor potassium ferricyanide produces any apparent change within 1 hr. at room temperature.

Certain other acyl derivatives of dihydrovitamin K_3 undergo oxidation to a quinone. Thus, ceric sulphate rapidly oxidizes the disulphate[16] {I : $R_1 = R_2 = SO_3(OH)$}, presumably to the quinone (II : $R_3 = H$), while bromine in aqueous solution reacts with both the acetate-phosphate {I : $R_1 = CO.CH_3$; $R_2 = P(O)(OH)_2$} and the mono-acetate {I : $R_1 = CO.CH_3$; $R_2 = H$} to give 3-bromo-2-methyl naphtho-1 : 4-quinone {II : $R_3 = Br$}. This nuclear bromination is in contrast to the behaviour of synkavit and naphtho-1 : 4-quinol (I : $R_1 = R_2 = H$), both of which give the quinone (II : $R_3 = H$). Since the diacetate (I : $R_1 = R_2 = CO.CH_3$) is unaffected by bromine in aqueous dioxan, the phosphorylated phenol groups appear to be polarizable and in this sense still phenolic.

The bromination of the acetate-phosphate probably follows the course:



the oxidation being accompanied by a phosphorylation (by PO_3^-) and an acetylation (by $CH_3.CO^+$ or its equivalent). In the case of synkavit, two phosphorylations should accompany the oxidation, the intermediate decomposing thus:



Since the quinone produced might itself act as an oxidizing agent, a cascade process can be envisaged:

$$\text{Quinol}_A \text{ diphosphate} \xrightarrow{-2 \text{ electrons}} \text{Quinone}_A + 2 \text{ phosphorylations}$$

$$\text{Quinol}_B \text{ diphosphate} + \text{Quinone}_A \rightarrow \text{Quinol}_A + \text{Quinone}_B + 2 \text{ phosphorylations, etc.}$$

By such processes, a considerable number of phosphorylations might arise from the initial transfer of two electrons, and the complications of multiple P/O ratios[18] in oxidative phosphorylation *in vivo* might originate in processes of this general nature.

Further details of this work will be published elsewhere. We are indebted to Dr. D. H. Marrian (Department of Radiotherapeutics, Cambridge) and Dr. K. J. M. Andrews (Roche Products, Ltd.) for helpful discussion and the provision of certain materials.

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A LOGARITHMIC TIME SCALE FOR THE EVOLUTION PROCESS

IN a recent article Sir Julian Huxley[1] made "in passing" a plea for a rational time unit and himself proposed the "cron": equivalent to a million years and to be modified by the usual metric multiples and sub-multiples (for example, one millicron would signify a millennium).

This certainly reduces the number of digits normally required to define the geological epochs; but perhaps the mechanism for this already exists. It is true that the phrase 'million years' proves tedious in repetition and its abbreviation 'M.Y.' undesirable—even ambiguous. Equally, the exponential form (for example, 10^6 years) may well be considered æsthetically objectionable in prose, albeit useful in diagrams.

But if a rational time unit is sought that will simplify the expression of geological and cosmic

Table 1. Some Typical Dates in the Logarithmic Scale of Elapsed Time

Log cycle	Dominant feature	Age		$\log_{10}$ years
		Cosmic time zero		(?) 9·7
9th	Zoögenesis	Azoic		?
		Archæozoic		Began 9·2
		Proterozoic		,, 8·9
		Palæozoic	Cambrian	,, 8·7
			Ordovician	,, 8·6
			Silurian	,, 8·55
			Devonian	,, 8·5
8th	Heterotherma		Carboniferous	,, 8·4
			Permian	,, 8·3
		Mesozoic	Triassic	,, 8·25
			Jurassic	,, 8·2
			Cretaceous	,, 8·0
		Cenozoic	Palæocene	,, 7·85
			Eocene	,, 7·8
7th	Homotherma		Oligocene	,, 7·4
			Miocene	,, 7·25
6th	Anthropoids	Pliocene		,, 6·8
	Homo "erectus"	Pleistocene	Eolithic	,, 5·9
5th	Neander-thaloids		Palæolithic	,, 5·7
			Acheulian	,, 5·6
			Mousterian	,, 5·15
			Aurignacian	,, 4·9
4th	Homo sapiens		Magdalenian	,, 4·7
			Mesolithic	,, 4·3
			Neolithic	,, 4·0
		Cultivation		,, 3·9
3rd	Civilization	Writing		,, 3·7
		Metallurgy		,, 3·6
		Christianity		,, 3·3
		Printing		,, 2·8
2nd	Organization	Industry, steam power		,, 2·3
		Electrical power		,, 2·2
		Internal combustion		,, 2·1
		Air flight		,, 1·95
1st	Expansion	Atomic energy		,, 1·8
		Space flight (?)		,, 1·6

Time reference point employed : A.D. 2000

time—and with equal elegance embrace the recent, historic past—then the logarithmic characteristic would seem attractive. It is true that there is little direct evidence for natural selection speeding the rate of biological evolution. Zeuner[2] has discussed the logarithmic increase of an isolated type, and Simpson[3] specifically contrasted rates for mammals and ammonites. Yet, writing from the point of view of an organic chemist with a limited, superficial knowledge of both prehistoric and recorded time, one must confess to being impressed by the apparent, overall exponential acceleration of evolutionary processes—cosmic, organic, social.

Thus it seems logical to replace a linear time-scale with a logarithmic one. Such a scheme, it is suggested, would give a 'new look' to geochronology. The non-specialist is offered a simplified, overall qualitative picture of cosmic and terrestrial evolution on a novel quantitative basis. This does retain the innate disadvantage that elapsed time must be measured from a finite reference point (in Table 1 the year A.D. 2000 has arbitrarily been chosen), but this only affects values in the first cycle for a given generation of chronologists.

It should be noted that the phrase 'log cycle' is used in the mathematical sense, that is, one cycle includes all mantissa values bearing the same index of ten; it should not be confused with Zeuner's more general term "cycle".

As may be seen from Table 1, it is possible to look back through nine log cycles to an indefinite cosmic time zero (say, 5×10^9 years ago or 5 kilocrons) and observe the pattern of psychological, biological, geophysical and cosmic evolution fitting symmetrically into place. In the ninth (most distant) cycle, the origin of the universe, and hence our own earth, is accommodated. Primordial life diversifies in the sea, invades the land and conquers the air in the eighth, from the small (?) Mesozoic mammals of which arise the warm-blooded creatures that rule the next cycle. The anthropoids, dominating the sixth, are harbingers of 'near-man', at his best in the fifth cycle. The fourth is marked by the final supremacy of *Homo sapiens*, in whom the power of reason merits Dr. Huxley's new gradal term[1] "Psychozoa". The remaining three cycles contain typical major advances in man's own anagenesis: his ability to control his own environment. These three cycles may conveniently be labelled (say) 'civilization', 'organization' and (characteristically for the current century) 'expansion'. The arbitrary selection of events quoted in Table 1 might well include the more recent revolutions in (say) medicine, psychology or the natural sciences, although perhaps major political upheavals may be regarded as ephemeral.

While each log cycle is characterized by a 'dominant feature', a major modification does not take place precisely at the end of a cycle but is a gradual process. Through this scheme, each feature may be viewed in a linear pattern without the inherent disadvantage of a linear chronology: the grossly disproportionate times required for different evolutionary modifications.

In short, it is suggested that a logarithmic time-scale presents a shift of emphasis, a redispersion of the spectrum of evolution, wherein man's brief moment at his end of elapsed time achieves a reasonable perspective in his personal time-scale. As Sir Julian Huxley said, "man is equivalent in evolutionary importance to all other organisms taken together".

Acknowledgment is made to the Government Chemist, Dr. G. M. Bennett, for permission to publish this communication.

G. F. Phillips

Government Laboratory,
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London, W.C.2

[1] Huxley, J., *Nature*, **180**, 454 (1957).
[2] Zeuner, F. E., "Dating the Past", 1st edit. (Methuen, 1946).
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A logarithmic time-scale is clearly useful for visualizing evolution in its human (psycho-social) phase, where many authors have directed attention to the obvious acceleration of cultural and technological advance (and also of other processes, such as population-growth).

However, where one can quantify such processes, a logarithmic scale for the *process* may be more useful: plotted semi-logarithmically against an absolute time-scale, it enables one to see at a glance changes in the rate of the process (for example, for population-growth, see refs. 1 and 2). For particular processes we may often expect to find clear evidence for a cycle of changes in rate, ending in stasigenesis (stabilization), following an anagenetic acceleration. Population growth has not yet begun to be stabilized.

In biological evolution we should expect to find similar cycles, involving slow initial rate of change followed by rapidly accelerating rate and ending in stabilization, whenever we can quantify advance in particular processes or of particular types[3].

But I am dubious whether there has been any acceleration of bio-evolutionary change in general,

notably in regard to increase of organization; and even if this could be demonstrated, it would prove to be of a different order from that found in cultural (human) evolution, so that the single logarithmic time-scale for all sectors of evolution proposed by Mr. Phillips would be misleading, in disguising the existence of major changes of rate (and type of process) at critical points in the overall process.

Thus, I should deprecate the use of a logarithmic time-scale as our main instrument in thinking about evolutionary time as a whole, while welcoming its use for specific purposes, in particular for clarifying our thought about evolution in the human (psychozoic) sector.

Julian Huxley

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A MODEL SYSTEM FOR CYSTEINE DESULPHYDRASE ACTION: PYRIDOXAL PHOSPHATE–VANADIUM

By Prof. F. BERGEL, R. C. BRAY and K. R. HARRAP

Chester Beatty Research Institute, Institute of Cancer Research: Royal Cancer Hospital, Fulham Road, London, S.W.3

OUR continued interest in the role of enzyme systems in the processes of normal and abnormal growth[1] has prompted us to extend our investigations to the pyridoxal phosphate-dependent enzyme desulphydrase, which catalyses the decomposition of cysteine, liberating hydrogen sulphide. Cysteine desulphydrase has been studied by Fromageot, Chatagner, Smythe and others[2–5], but no procedures for intensive purification have been reported.

This communication describes a model system for the enzyme consisting of pyridoxal phosphate and a vanadium salt. Snell *et al.*[6] have carried out very important *in vitro* studies on the activation of pyridoxal by various metal ions in reactions such as transamination, α–β elimination and others, and they found[7] that a pyridoxal–aluminium combination was effective in promoting the decomposition of serine and cysteine at *p*H 5·0 and 100° C.

In similar experiments, but at room temperature and with pyridoxal phosphate, we observed in the presence of aluminium ($Al_2(SO_4)_3.K_2SO_4.24H_2O$) a ready evolution of hydrogen sulphide, accompanied by the formation of a white precipitate. With cobalt ($Co(NO_3)_2.6H_2O$) in place of aluminium a low rate of hydrogen sulphide evolution was obtained. These experiments were carried out under nitrogen at *p*H 5·0 in acetate buffer at about 25° C., the hydrogen sulphide estimations following the method of Bray[8], which represents a continuous removal of hydrogen sulphide from the reaction mixture.

For reasons arising from our working programme in the field of trace metals[9], and in order to obviate the precipitation mentioned above, we investigated a number of transition metals such as molybdenum, uranium and vanadium which have never been reported as activators of *in vitro* catalysis by pyridoxal phosphate. While ammonium molybdate and uranyl acetate were of little use, vanadium in the form of ammonium vanadate or vanadyl chloride or sulphate proved to be extremely effective, giving a rate of hydrogen sulphide evolution from cysteine of about eight times that obtained from an equivalent quantity of aluminium. This surprisingly high desulphydrase-like action of vanadium salts in combination with pyridoxal phosphate showed a reaction optimum at *p*H 6·0 (0·1 *M* phosphate buffer); the rate of hydrogen sulphide evolution for fixed quantities of pyridoxal phosphate and ammonium vanadate (each 0·4 m*M*) was approximately proportional to the cysteine concentration in the range of 0·5–13 m*M* cysteine (Fig. 1*a*), but reached maxima for certain concentrations of pyridoxal phosphate or of vanadium where the concentrations of the two other constituents were kept constant (Fig. 1*b* and *c*, respectively). Thus with 0·4 m*M* ammonium vanadate and 13 m*M* cysteine maximum effects were obtained in the presence of about 8 m*M* pyridoxal phosphate. On the other hand, with 0·4 m*M* pyridoxal phosphate and 13 m*M* cysteine, optimal activity was achieved only in the presence of 0·4 m*M* ammonium vanadate, concentrations in excess of this leading to progressively lower hydrogen sulphide rates.

In addition to hydrogen sulphide, ammonia and pyruvic acid were produced. Paper chromatographic examination of a reaction mixture using higher reactant concentrations than those reported here indicated the presence of alanine. Other reaction products which would account for the quantitative discrepancies below are yet to be identified. Ammonia determinations were carried out according to the method of Brown *et al.*[10], and pyruvic acid estimations

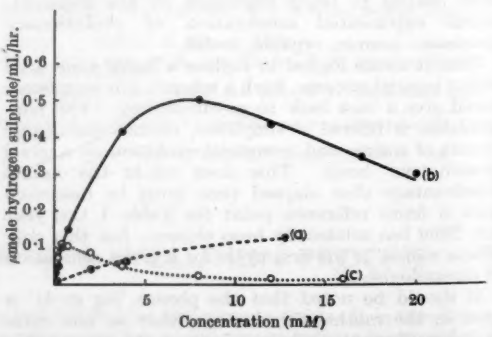

Fig. 1. (*a*) Variation in rate of evolution of hydrogen sulphide with cysteine concentration. Pyridoxal phosphate and ammonium vanadate concentrations held constant at 0·4 m*M*. (*b*) Variation in rate of evolution of hydrogen sulphide with pyridoxal phosphate concentration. Ammonium vanadate and cysteine concentrations held constant at 0·4 m*M* and 13 m*M*, respectively. (*c*) Variation in rate of evolution of hydrogen sulphide with vanadium concentration. Pyridoxal phosphate and cysteine concentrations held constant at 0·4 m*M* and 13 m*M*, respectively

by that of Friedman and Haugen[11]. The method of Hardy *et al.*[12] was adopted for the qualitative detection of alanine.

The yield of identified products obtained from a number of runs, after 24 hr. at 37° C. (when reaction is virtually complete) using solutions 1·2 m*M* with respect to cysteine and 0·24 m*M* with respect to pyridoxal phosphate and vanadium were: hydrogen sulphide about 70 per cent, pyruvic acid and ammonia, each about 14 per cent.

The following additional observations are of interest: (1) estimation of the residual cysteine sulphur after 24 hr. at 37° C. gave results confirming that about 70 per cent of the amino-acid had been decomposed. (2) The addition of a quantity of alanine, equivalent to the cysteine present in a reaction mixture, had no effect on the initial rate of evolution of hydrogen sulphide. However, with an equimolecular mixture of cysteine and serine, the initial rate was 20 per cent lower than that with cysteine alone. (3) An equimolecular mixture of cysteine and cystine, on the other hand, produced hydrogen sulphide at a rate six times that with cysteine alone and forty-eight times that with cystine alone. The above results indicate a certain degree of specificity of the pyridoxal phosphate–vanadium system for cysteine–cystine degradation. It is hoped that further work will lead to an elucidation of the underlying mechanism of reaction.

When our colleague, Dr. R. J. C. Harris, applied the combination to the *D–R"D"* fowl sarcoma and the Rous fowl sarcoma, implanted in the chorio-allantoic membrane of eggs, inhibition of growth of the tumours was observed in both cases, with no growth inhibition of the embryo in the latter, and only a small inhibition in the former case. In control experiments with the single components at the same concentrations, no such growth inhibition of the tumours occurred. These effects, together with the catalytic properties found *in vitro*, prompt speculations as to whether vanadium may be involved along with pyridoxal phosphate in functional protein systems[13–15], regulating, for example, sulphur metabolism. We have started to explore such possibilities.

We are grateful to Prof. A. Haddow for his continued interest in our work. The work has been supported by grants to the Chester Beatty Research Institute (Institute of Cancer Research: Royal Cancer Hospital) from the British Empire Cancer Campaign, the Jane Coffin Childs Memorial Fund for Medical Research, the Anna Fuller Fund, and the National Cancer Institute of the National Institutes of Health, U.S. Public Health Service.

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INFLUENCE OF SOME IODOAMINO-ACIDS AND IODOPROTEINS ON THE GROWTH OF *CORCYRA CEPHALONICA* ST.

By N. R. MOUDGAL, E. RAGHUPATHY and Prof. P. S. SARMA
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ADDITION of small amounts of thyroxine to the diet of the rice moth larva (*Corcyra cephalonica* St.) has been shown[1] to accelerate the growth and the rate of oxygen consumption of the larva. Thyroglobulin, however, at the concentrations tried, neither had any growth-promoting activity nor did it influence the rate of oxygen consumption of the larva. The results obtained with other iodoamino-acids and with iodocasein on the growth and metamorphosis of the larvæ are reported here.

The preparation of the diets and the general technique involved in rearing the larvæ have been described earlier[1–3]. Thyroxine, triiodothyronine and thyroxamine were added to the diet as solutions in 0·001 *N* sodium hydroxide, and thyroglobulin and iodocasein as protein–lactose mixtures. The test compounds were tried over a wide range of concentrations. The food after the addition of test compounds was well mixed with sufficient distilled water to form a uniform paste, dried at 60° C., ground and used. Growth was measured by weighing the larvæ at the end of 20 days on the experimental diet.

Srinivasan, Moudgal and Sarma[1], using *Corcyra* eggs as the initial seed material, observed the optimal concentration of l-thyroxine to be at 0·75 μgm. per gm. food. In the present series of experiments, the 7–8-day-old larvæ which were used as the initial seed material (30 larvæ of 4–5 mgm. wt.), seem to withstand the toxicity of the test compounds better than the freshly hatched larvæ, and hence exhibit a higher optimal concentration of 2·0 μgm. of l-thyroxine per gm. diet (Table 1). This concentration of thyroxine proved optimal even when larvæ of varying age, as from 5 to 10 days, were used as the initial seed material. l-Triidothyronine and thyroxamine produce an optimal growth increase when included in the diet at a level of 0·10 μgm. and 3·0 μgm. per gm. diet respectively. Thus, whereas in mammals and tadpoles triiodothyronine is only 5·0 and 5·6 times as active as thyroxine, in *Corcyra* it is nearly 20 times as effective as thyroxine. Thyroxamine has very little effect on higher animals, whereas it simulates thyroxine action in amphibians and lower vertebrates[4]. It may be of interest to recall here Pitt-Rivers's[4]

suggestion that lower vertebrates are unable to differentiate any slight modification in the alanine side-chain of thyroxine, and hence respond to these compounds in a manner similar to thyroxine. Our present results with rice moth larvæ indicate that invertebrates too may behave in a similar manner.

Thyroglobulin and iodocasein produce maximal growth increase when included at a thyroxine equivalent concentration of 5·6 μgm. and 10 μgm. per gm. diet respectively (Table 1). *In vitro* experiments carried out with *Corcyra* extracts showed the digestibility of thyroglobulin to be very poor when compared with iodocasein and casein (unpublished results), and this may explain in part the high thyroxine-level at which thyroglobulin is effective in *Corcyra*. This may also be responsible for the lack of effect observed earlier[1], when thyroglobulin was included in the diet over a thyroxine concentration of 0·06–2·6 μgm. per gm. food.

Table 1. Effect of Thyroxine, Triiodothyronine, Thyroxamine, Thyroglobulin and Iodocasein on the Growth of Rice Moth Larvæ (*Corcyra cephalonica* St.)
Initial seed material 30 (7–8 day old) larvæ per dish

Test compounds	Concentration range of test compound (μgm./gm. diet)	Optimal concentration of test compound (μgm./gm. diet)	Weight of 10 larvæ at the end of 20 days on the experimental diet (mgm.)
Control	—	—	200
l-Thyroxine	0·75– 5·00	2·00	327
l-Triiodothyronine	0·05– 2·00	0·10	434
Thyroxamine	0·10– 5·00	3·00	310
Thyroglobulin*	1·40–11·20	5·60	280
Iodocasein*	0·50–10·00	1·00	276

* Concentration expressed in terms of thyroxine

Table 2. Effect of Thyroxine, Triiodothyronine, Thyroxamine, Thyroglobulin and Iodocasein on the Moth Emergence of Rice Moth Larvæ
Initial seed material 25 (7–8 day old) larvæ per dish

Test compound	Concentration of test compound (μgm./gm. diet)	Total number of moths	Days over which moth emergence ranged
Control	—	12	41–49
l-Thyroxine	3·0	19	38–45
l-Triiodothyronine	0·2	17	35–40
Thyroxamine	4·0	19	37–47
Thyroglobulin*	5·6	16	35–44
Iodocasein*	2·0	17	33–44

* Concentration expressed in terms of thyroxine

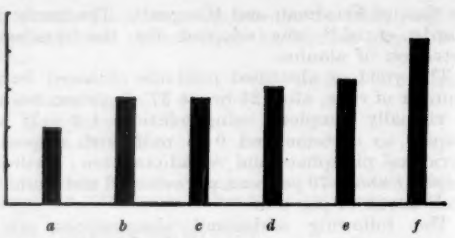

Fig. 1. Relative growth-promoting effect of thyroxine, triiodothyronine, thyroxamine, thyroglobulin and iodocasein when fed at their optimal concentrations to *Corcyra* larvæ. The figure represents the weight of 10 larvæ at the end of 20 days growth on the various experimental diets. *a*, Control; *b*, iodocasein; *c*, thyroglobulin; *d*, thyroxamine; *e*, thyroxine; *f*, triiodothyronine

The relative growth-promoting effect of all these compounds at their optimal concentrations is represented in Fig. 1. It is clear that triiodothyronine, apart from being 20 times as active as thyroxine, produces the maximal growth response. Iodocasein and thyroglobulin, on the other hand, enhance the growth of *Corcyra* only to a limited extent.

It is evident from Table 2 that all the test compounds influence the metamorphosis of the rice moth larva into the adult moth. Apart from accelerating the onset of emergence of the moth from the pupa, the percentage of larva reaching maturity is also high, as can be made out by the total number of moths.

We are grateful to Hoffmann La-Roche and Co., Basle, Switzerland, for a generous gift of thyroxamine used in the above investigation. Details of this investigation will be published elsewhere.

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TWO CRYSTALLINE HÆMOPROTEINS OF WHEAT

Crystallization of Wheat Germ Hæmoproteins with α-Bands at 556 mμ and 566 mμ

As described in an earlier communication[1], extract of wheat germ was precipitated with ammonium sulphate, treated with acid, then fractionated with ammonium sulphate into two fractions, precipitated at 40–75 per cent and 75–95 per cent saturation, and the former fraction was used here. The precipitate (prepared from 10 kgm. wheat germ) was dissolved in water, dialysed against tap-water, adjusted to *p*H 6·0, and then a large amount of the resultant precipitate was removed after cooling the suspension below 2° C. The 3·5 l. of filtrate was adjusted to *p*H 6·0 and passed through a column of 'Duolite' *CS*-101 (100–200 mesh, 3 cm. × 30 cm.) buffered with 0·02 *N* (0·02 gm.-ion of NH_4^+) ammonium phosphate buffer at *p*H 6·0. (The purity of hæmoprotein (556)—defined as hæmoprotein with α-band at 556 mμ—expressed as the ratio of extinction at 280 mμ to that at 411 mμ at *p*H 10, R_{280}^{411}, was lower than 0·1. Here 411 mμ is the absorption maximum of oxidized hæmoprotein (556) at alkaline *p*H.) Almost all the hæmoproteins (556) and hæmoprotein (566) were adsorbed on the column, though the latter was very small in amount. The column was washed with a large amount of 0·02 *N* buffer, *p*H 7·0, then the pigments adsorbed on the column were eluted with 0·4 *N* buffer of *p*H 7·0. The eluate (150 ml.; *R*, 0·3) was dialysed, adjusted to *p*H 6·5, then passed through a column of 'Amberlite' *XE*-64 (3 cm. × 5 cm.) buffered at 0·05 *N* ammonium ion and *p*H 6·5. The column was washed with 0·05 *N* buffer, *p*H 6·5, and then 0·25 *N* buffer was passed for the elution (eluate, 100 ml.; *R*, 1·4).

The above eluate, which contained a considerable amount of hæmoprotein (556) and a small amount of hæmoprotein (566), was dialysed, passed through a

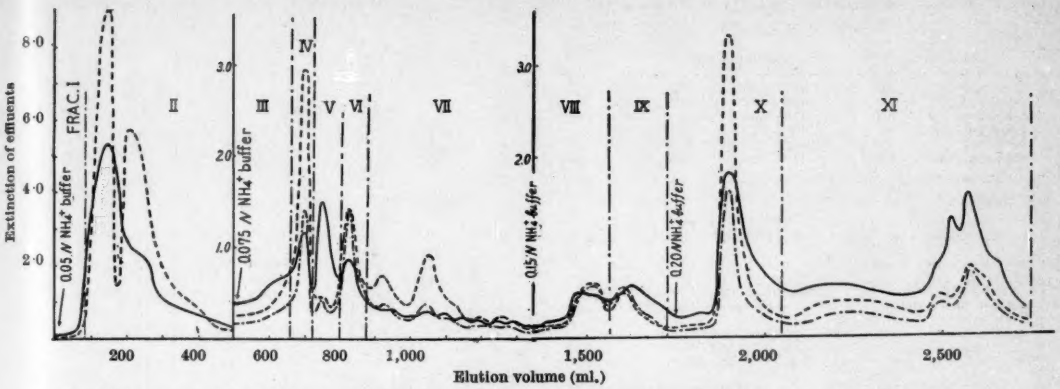

Fig. 1. Chromatography of hæmoproteins of wheat germ : – – –, extinction at 411 mμ, *p*H 10 ; – . – . –, extinction at 417 mμ, *p*H 7 ; ——, extinction at 280 mμ, *p*H 7

column of 'Amberlite' *XE*-64 equilibrated with 0·05 *N* ammonium buffer of *p*H 7·0, and then chromatographed by passing, successively, 0·05, 0·075, 0·10, 0·15 and 0·20 *N* buffer of the same *p*H. A typical chromatogram thus obtained is shown in Fig. 1.

Fraction II (400 ml. ; *R*, 2·0) and fraction IV (75 ml. ; *R*, 2·5) in Fig. 1 contained most of the hæmoprotein (556) present, and they were combined and fractionated with ammonium sulphate. The fraction which was precipitated between 50 and 75 per cent saturation was dissolved and dialysed (dialysed filtrate, 40 ml. ; *R*, 2·6), then rechromatographed on the column treated with 0·04 *N* buffer at *p*H 7·0, using 0·04 and 0·05 *N* buffer successively. The hæmoprotein (556) was divided into three major fractions which showed extinction ratios of 3·5, 4·5 and 3·0, respectively, together with four small fractions of lower purities. The results of chromatography varied from experiment to experiment, but usually two or three fractions containing large amounts of hæmoprotein (556) of high purity were obtained.

The fraction containing the purest pigment was fractionated with ammonium sulphate, and the precipitate between 60 and 75 per cent saturation was dissolved in a minimum amount of water. The solution was adjusted to *p*H 7·0 and saturated ammonium sulphate solution was added at 0° C. until the solution became slightly turbid. The turbid precipitate was dissolved by cooling to −6° C., and then the solution was allowed to warm up very slowly until the temperature reached 10° C. During this period the crystals appeared as brownish-red plates (Fig. 2).

Fig. 2. Crystalline hæmoprotein (556) of wheat germ (× 450)

From fraction VI of the first chromatogram (Fig. 1), hæmoprotein (566) was also crystallized as rosettes in a similar manner, except that in this case fractionation with ammonium sulphate was carried out between 55 and 65 per cent saturation. The yield of the crystals was very small, about 20 mgm., from 5 kgm. of the germ, whereas that of crystalline hæmoprotein (556) was about 80 mgm.

Properties of Crystalline Hæmoproteins with α-Bands at 556 mμ and 566 mμ

Both crystalline hæmoproteins with α-bands at 556 mμ and 566 mμ were quite soluble in water ; the former pigment was precipitated almost completely with ammonium sulphate at 70 per cent saturation, while the latter was precipitated at 65 per cent saturation. The solution of hæmoprotein (556) was brown in colour below *p*H 6·5 but reddish-pink like cytochrome *c* at *p*H values higher than 7·5, owing to the reversible variation of its absorption spectrum with *p*H (Fig. 3). The absorption spectrum of hæmoprotein (566), was the same at the *p*H range below 8·0 and rapidly lost its typical absorption bands at higher *p*H by irreversible denaturation.

As shown in Fig. 3 and Table 1, oxidized hæmoprotein (556) combined with cyanide and fluoride, and the absorption spectra of these complexes resembled those of the corresponding complexes of horse-radish peroxidase[3], while no marked change in the spectrum of oxidized hæmoprotein (566) was observed by the addition of cyanide and fluoride. Both hæmoproteins were autoxidizable throughout the range of *p*H tested, especially at lower *p*H, and it was difficult to obtain the spectra of the completely reduced pigments, even if the solutions were covered with liquid paraffin. Therefore, the β-band of reduced hæmoprotein (566) was seen only as a shoulder in Fig. 4, although this band was sometimes observed distinctly by a hand spectroscope. When cyanide was added to a solution of hæmoprotein (566) together with sodium dithionite, the observed absorption maxima (namely, the α-, β- and γ-bands) were the same as those obtained without the addition of cyanide, but the extinction value at each peak,

Table 1. Summary of Absorption Spectra of Hæmoprotein (556)

Derivative	Maximum (mμ)	Minimum (mμ)
Oxidized *p*H 7·0	397 495 635	455 599
Oxidized, F^- *p*H 4·0	406 490 612	460
Oxidized, CN^- *p*H 7·0	418 534	500 580
Oxidized, alkali *p*H 9·5	408 523	490
Reduced *p*H 9·5	432 525–530* 556	485
Reduced, CO *p*H 9·5	419 538 566	490 555

* Shoulder.

Table 2. Summary of Absorption Spectra of Hæmoprotein (566)

Derivative	Maximum (mμ)	Minimum (mμ)
Oxidized *p*H 7	417 540	510
Reduced *p*H 7	433 535–540* 566	494
Reduced, CN^- *p*H 7	433 535 566	495 549
Reduced, CO *p*H 7	422 540 552–567*	499

* Shoulder.

especially at the β-band, was much higher in the presence of cyanide than in its absence (Fig. 4). It is supposed that the increased absorption intensities observed after the addition of cyanide is not caused by the combination of cyanide with reduced hæmoprotein (566), but is due to the protection by cyanide from autoxidation.

The spectrum obtained in the presence of cyanide may, therefore, represent the true spectrum of the completely reduced hæmoprotein (566). Carbon monoxide combined with reduced hæmoprotein (566), causing changes in that spectrum but not with the oxidized hæmoprotein. In this respect, hæmoprotein (566) differs from mammalian cytochrome *b*[3], which shows no marked change in spectrum on the addition of carbon monoxide to the reduced state, although the two pigments exhibit very similar spectra in the reduced as well as in the oxidized state.

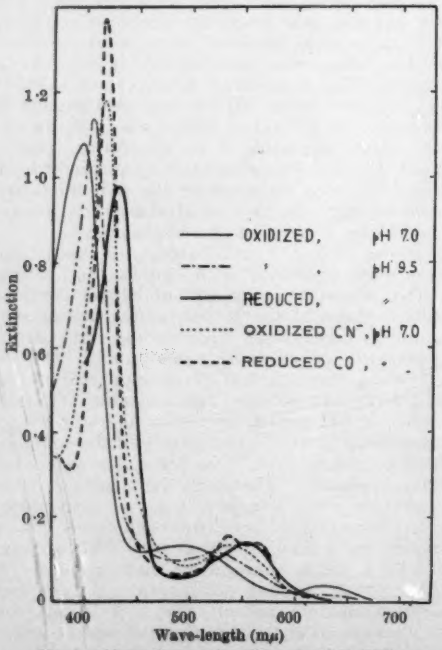

Fig. 3. Absorption spectra of hæmoprotein (556)

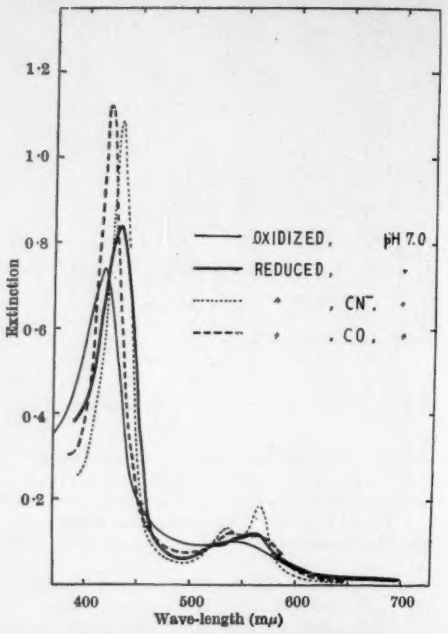

Fig. 4. Absorption spectra of hæmoprotein (566)

Both hæmoprotein (556) and (566) were found to possess very strong peroxidatic activities (roughly 50 per cent as active as crystalline Japanese radish peroxidase[5]) when measured by the modified method of Willstätter *et al.*[4]. However, the two pigments were both very unstable in hydrogen peroxide solution and rapidly inactivated at any *p*H in which crystalline peroxidase of Japanese radish was quite stable.

In view of the strong peroxidatic activity of the hæmoproteins and of the changes in their absorption spectra produced by the addition of some reagents, it appears that these pigments, especially hæmoprotein (556), are related to peroxidase. However, we tentatively use the name hæmoprotein for both pigments until the classification of cytochromes is further clarified[6].

We wish to thank Nisshin Flour Milling Co., Ltd., for supplying the wheat germ, and also Dr. Morita, of Kyoto University, for the crystalline Japanese radish peroxidase.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

A New British Fish (*Gobius forsteri*)

For the past four or five years, Mr. G. R. Forster, of this Laboratory, has, with aqualung equipment, been making a study of the fauna of sub-littoral reefs and cliffs on the open coast-line near Plymouth. As well as detailed station work at Revelstoke Point, east of Plymouth, and at Queeners Point on Rame Head at the western entrance to Plymouth Sound, he has made dives off St. Helier in the Channel Islands, and off Santander in Spain.

In all these localities, and at points along the Devon and south Cornwall coast from Hope Cove near Bolt Tail to off the mouth of the Helford River, he has seen a goby which is certainly new to the British fauna and also, I believe, to the European fauna, since I have not been able to identify it in published works.

Mr. Forster has caught specimens of this goby up to 12 cm. in length; it is robust and very similar in build to the common rock goby, *G. paganellus*. Its colouring is surprisingly brilliant and arresting: large and conspicuous bright orange or brick-red spots are evenly disposed in a regular pattern on a pale straw-brown ground colour. On the nape, midway between the eyes and the first ray of the first dorsal, is a large orange spot ringed by eight others, four on each side of the midline. Continuing towards the tail, other pairs flank the dorsal fins and there are six large orange spots on the sides of the body—a pattern seen in many *Gobius* species—with smaller intermediate ones. On the dorsal fins there are longitudinal bands and spots of this orange and the hind part of the first dorsal is black, again as in many gobies. Scales are entirely absent from the opercula and from the head and shoulders as far back as the first ray of the first dorsal. There are prominent lines of papillæ on the head. In Part 2 of "The Open Sea", there is a coloured illustration of this fish[1].

Gobius forsteri lives in rock fissures in the sides of gullies or under large boulders in a depth of between 4 and 6 fathoms on the open coast or where there are considerable reefs or precipitous cliffs. It does not occur in waters with a marked estuarine influence: Duke Rock, in the eastern channel out of Plymouth Sound, is the closest inshore that Mr. Forster has seen it. Its extreme shyness and quickness make it very difficult to catch, and this has been seen in specimens which Mr. Forster has now kept in one of the laboratory tanks for more than two years: they have not become at all tame, as do many fish kept in an aquarium. They bred, however, in the tank in 1956 and 1957; eggs were laid in a typical single layer on the underside of flat stones and on the tank side in May, June and July. They were guarded by the male, and the young hatched after about a week. During courtship and incubation, the colouring of the male is intensified and the ground-colour darkens almost to a black-purple.

The following fin-ray and lateral-line scale counts are from three preserved and six living specimens; the latter were narcotized with urethane for handling:

D_1	D_2	A	Lateral line scales L. H. S.	R. H. S.
5	13	12	35	37
5	13	12	36	37
6	13	12	34	37
6	13	12	37	—
6	13	12	35	36
6	13	12	35	36
6	13	12	38	36
6	13	12	36	37
7	14	12	37	36

In the first dorsal fin of all specimens, there is a markedly larger interval between the last and the penultimate fin-ray, a little more than twice the interval between the other rays at their point of insertion.

I am very much indebted to Mr. G. R. Forster for all the information he has given to me about this species, and it is a pleasure to name it after him.

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Coexistence of Three Species of the Wood-boring Isopod *Limnoria* in Southampton Water

Three species of *Limnoria*, *L. lignorum* (Rathke), *L. quadripunctata* Holthuis and *L. tripunctata* Menzies, have been found living together in piling and test blocks taken from Southampton Water. This is the first European record for *L. tripunctata*, which previously has been reported only from Central and North America[1]. This species has since been found with *L. quadripunctata* in piling taken from Cowes, Isle of Wight, and from Swansea, South Wales, where it was the only species present in the samples examined.

No evidence has been found that interbreeding between the species occurs in Southampton Water. All animals in laboratory colonies founded from a number of gravid females of the same species showed the specific characters of the original females. In all cases in which the young post-larval stages were examined from the brood pouch, the species characters of the parent were present. On several occasions males and females of different species were found in the same burrow, but there was no indication of reproduction and in no case was a gravid female taken with a male of a different species. It is probable that migrant *Limnoria* will enter any burrow, for pairs of the same sex and even three animals have been found together.

The specific composition of a series of test block samples taken from Southampton docks during a twelve-month period differed from that of a similar series taken from Calshot, at the mouth of Southampton Water. A further difference occurred between test-block and piling samples from the same locality (Table 1).

Table 1

	Test blocks		Piling	
	Southampton	Calshot	Southampton	Calshot
No. examined	1,444	1,909	751	1,165
L. lignorum (per cent)	43	19	6	3
L. quadripunctata (per cent)	47	46	37	33
L. tripunctata (per cent)	10	35	57	64

The *Limnoria* species tended to occur in discrete groups in piling, and it is probable that migratory activity resulted in more heterogeneous test-block populations. The migrant (test-block) *Limnoria* may therefore represent a natural sample of the species present, and hence the test-block samples are more likely than those from piling to indicate the proportion of species present in the total *Limnoria* population.

Specific differences in migratory and reproductive behaviour have been found and the results are being prepared for publication.

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April 20.

[1] Menzies, R. J., Bull. Marine Sci. Gulf and Caribbean, 7, 101 (1957).

Pathological Parthenogenesis in Viviparous Toothcarps

In addition to the cases of parthenogenesis described by Spurway[1] in *Lebistes reticulatus* (Peters) we have observed three new cases: two in the same species, and one in *Xiphophorus helleri* Heckel.

The first case with *Lebistes* involved a female isolated immediately after birth and thus free from any contact with the male sex. When this female reached the age of 18 months and a length of 46 mm. the so-called pregnancy spot occurred, that is, a dark-pigmented spot in front of the tail base on the ventral side, which is characteristic of pregnancy. After some time 22 young fishes were born, which during growth were, without exception, found to be female.

The second case with *Lebistes* was very similar. After reaching a length of 37 mm. at the age of 15 months this virginal animal dropped 14 young fishes, all female.

The virginal *Xiphophorus* female showed a similar behaviour. This animal too was completely isolated immediately after birth. When the fish had reached a length of 71 mm., it showed the pregnancy spot and some time afterwards 28 female young fishes were born. After this the animal became pregnant again, resulting in the birth of young fishes, also exclusively female.

Microscopic examination of mother animals revealed that the sperm chambers of the ovaries contained no spermia. This finding excluded self-fertilization, a phenomenon incidentally seen in viviparous toothcarps and explained by the presence of a bisexual gonad, which produces spermia as well as oocytes.

Another important finding was a pathological process localized in the ovaries and in their surroundings. This was an infection with the *Ichthyophonus* parasite, the phycomycete *Ichthyophonus hoferi* Plehn-Mulsow. The cysts appeared to be situated in the cranial part of the ovaries and in the adjacent regions. Birth would undoubtedly have been prevented if an extensive process had been localized in the caudal parts of the ovaries and near the junction between ovary and oviduct.

The association of parthenogenetic development on one hand, and the occurrence of an *Ichthyophonus* infection on the other, seem to justify the assumption that the cause of parthenogenetic development in these cases is a pathological process. In any event, it could be assumed that the *Ichthyophonus* toxin in these cases provided the artificial stimulus for the development of unfertilized oocytes.

On the strength of these results, we consider it justified to launch the hypothesis of 'pathological parthenogenesis'. By this we mean the development of the unfertilized oocytes due to the influence of a pathological stimulus. Experimental embryology has shown that various stimuli are capable of causing an oocyte to develop without fertilization. The developmental ability was apparently localized in the oocyte itself, and the invading spermia involved in the normal fertilization, and the chemical and physical stimuli used in artificial parthenogenesis, merely serve to eliminate an inhibiting factor, a buffer which impairs development.

On the basis of purely theoretical considerations it is conceivable that a pathological process, localized in the ovaries or in their immediate surroundings, is likewise capable of removing this buffer and of causing development of the unfertilized oocyte. The parthenogenetic stimulus might in such a case consist of toxic substances, or possibly decomposition products liberated in the course of tissue necrosis. From this point of view pathological parthenogenesis may be regarded as a form of artificial parthenogenesis, effected not so much by experimental intervention as by Nature itself.

In our opinion it is undoubtedly possible that the cases of parthenogenesis in *Lebistes* described by Spurway might also involve a pathological process, probably an *Ichthyophonus* infection, which is by no means uncommon in fish; indeed its incidence is very high, particularly in the viviparous toothcarps, as it is highly infectious. Naturally, this does not eliminate the possibility of another pathological process. Experiments in artificial parthenogenesis have shown that the stimulus required need not be at all specific.

In view of these results it would be advisable, in new cases of parthenogenesis, to make a systematic investigation into the possible presence of a pathological process in the ovary or in the immediate vicinity of this organ. So far as I know this has not yet been done, or at least not on an adequate scale.

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Nutritional Anæmia in Mink

Nutritional anæmia in mink has been described by Kennedy[1] and Whithair *et al.*[2]. In recent experiments we observed that mink kits fed diets containing large amounts of raw coalfish (*Gadus virens*) developed anæmia and characteristic fur anomalies, especially light under-fur, in about 40 per cent of the animals. The same disorder was also seen in mink kits fed diets containing raw whiting (*Gadus merlangus*)[3]. A rather high mortality-rate of about 20–30 per cent was noted in the anæmic animals.

Development of anæmic symptoms and light under-fur could be totally prevented by replacing the dietary raw fish with boiled fish of the same species. The results obtained suggest a heat-labile factor capable of producing anæmia, probably an enzyme in the raw fish.

Table 1. Blood Picture of Mink fed Different Fish Diets. (Mean Values per Mink)

Diets	No.		Hæmoglobin (gm. per cent)	Erythrocytes (millions per mm.³)	Packed cell volume per cent (hæmatocrit)	Reticulocytes (per cent)	Leucocytes (thousand per mm.³)	Mean corpuscular volume	Mean corpuscular hæmoglobin concentration	Under-fur
	Mink	Samples								
Raw coalfish	29	29	10·6 6·9–16·2	7·8 4·7–11·9	30·0 17·0–42·0	2·3 0·1–7·0	14·66 3·0–37·4	39·6 25·0–55·7	35·5 26·3–48·2	White
Boiled coalfish	6	9	19·3 18·8–22·8	11·2 9·5–12·4	50·1 40·0–58·0	1·65 0·35–2·6	7·0 3·6–12·2	44·4 35·9–50·2	40·9 34·1–48·3	Grey–normal
Boiled coalfish + meat	16	38	18·5 16·2–22·8	10·7 9·0–12·8	52·6 46·0–64·0	1·63 0·9–2·63	4·5 1·8–6·8	50·0 42·2–57·8	34·5 30·0–38·5	Normal
Raw lumpsucker	8	8	17·6 15·2–20·4	11·0 9·0–12·1	43·6 32·0–54·0	1·6 1·2–2·1	7·3 3·4–10·4	40·4 27·6–51·9	41·96 34·3–55·0	Grey–normal

Investigations at this Research Station have shown the high frequency of anæmia in mink to be related to the feeding of certain species of raw fish belonging to the family Gadidae, especially coalfish and whiting. Other species belonging to the Gadidae have not hitherto been investigated. Various species of raw marine fishes (salt-water fish, ocean fish) which have been fed, such as lumpsucker (*Cyclopterus lumpus*), blue halibut (*Reinhardtius hippoglossoides*) and catfish (*Anarrhicas lupus*), produced neither anæmia nor symptoms of light under-fur.

These observations are based on feeding experiments with 350 mink. Forty out of ninety standard mink developed anæmia on an experimental diet with the following percentage composition: raw gutted coalfish (71), stockfish (10·6), dried skimmed milk (2·2), tallow fat (3·5), wheat starch (10·6), bone meal (1·4) and McCollum salt mixture (0·7). In addition, each animal received 1,500 I.U. vitamin A, 150 I.U. vitamin D, 0·7 mgm. aneurin, 2 mgm. α-tocopherol and 0·25 mgm. vitamin K daily. Many of the animals on this diet had reduced appetite, loose stools and did not grow well. The coat was very dull in appearance and the under-fur was white or greyish in colour, a disorder called 'cotton mink' by farmers. Anæmia developed at intervals during the experimental period from weaning to pelting time of about 5 months: twenty-three out of eighty standard mink fed raw whole whiting developed anæmia and light under-fur.

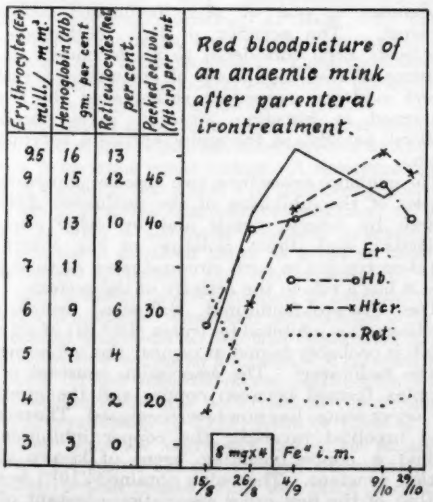

Fig. 1

In control experiments comprising in all thirty mink kits on a similar diet, but in which twenty kits were fed boiled whiting and ten were fed boiled coalfish, no single animal showed signs of anæmia or developed light under-fur.

In another experimental group of ten mink kits fed boiled coalfish supplemented with 20 per cent raw meat and 2 per cent brewer's yeast besides vitamins and minerals specified above, all animals were normal (Table 1).

The type of nutritionally induced anæmia was characterized by a low erythrocyte count and high leucocyte and moderately elevated reticulocyte counts (Table 1). Stained blood smears showed aniso- and poikilo-cytosis. The poikilocytosis was predominant in the extreme cases of anæmia. The picture of red cells showed a mixture of hypochrome normomacrocytes and hyperchrome macro- and microcytes.

Treatment of anæmic animals with organic preparations of iron brought recovery when administered parenterally twice a week (weekly dose, 16 mgm. organic iron). After ten days there was a definite increase in the hæmoglobin level (Fig. 1), which was maintained for several weeks after the treatment had been discontinued. Oral doses of 40 mgm. iron daily for three weeks gave some relief, although it was not so successful as the parenteral administration. Vitamins of the B complex (aneurin, 1 mgm.; riboflavin, 2·8 mgm.; calcium pantothenate, 10 mgm.; nicotinic acid, 12·6 mgm.; pyridoxin, 1·4 mgm.; folic acid, 0·26 mgm.; biotin, 0·2 mgm.; vitamin B_{12}, 0·01 mgm.; inositin, 10 mgm.; *para*-aminobenzoic acid, 25 mgm.; cholin chloride, 25 mgm.) in big oral doses had little prophylactic effect. Liver extract administered orally or parenterally gave some relief of the anæmic symptoms.

The mink used experimentally were all kept under ordinary farm conditions. Analysis of the coalfish used in our diets gave the following percentages: protein, 18·9; fat, 0·4; minerals, 3·1; dry matter, 22·4.

Studies are now in progress to ascertain the nature of this factor producing anæmia and the manner in which it acts.

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Effect of Antibiotics on the Phagocytic Activity of the Reticulo-Endothelial System

It was shown by Nicol and his co-workers[1,2] that œstrogens, both natural and synthetic, stimulate the phagocytic activity of the reticulo-endothelial system, while cortisone depresses phagocytosis, and also the total and differential white cell counts in the blood and the gamma-globulin level in the serum. On the other hand, if cortisone treatment is stopped, the depressant action of the cortisone can be reversed and converted into one of moderate stimulation by diethyl stilbœstrol; and, further, if cortisone and diethyl stilbœstrol are administered separately but at the same time, the depressant action of the cortisone is prevented and considerable stimulation of phagocytic activity occurs[3]. According to Florey[4] it is possible that some chemotherapeutic agents depend for their complete effectiveness on the action of phagocytes; he also states that in acute infections the organisms are generally killed or inhibited by the use of chemotherapeutic drugs.

The following research was designed to study the effect of antibiotics on the phagocytic activity of the reticulo-endothelial system to find out whether or not the phagocytes were actively stimulated and thus play an important part in the action of these drugs, and whether the results might be of interest in determining the choice of an antibiotic.

The present experiments were carried out on 120 male white mice (T.O. Swiss strain) of 18–25 gm. body-weight. The doses of the antibiotics and the routes of administration were arranged to be comparable with standard clinical and veterinary practice. Groups of 5–10 animals were used for assessing the effect of each antibiotic on the phagocytic activity of the reticulo-endothelial system, each animal receiving one dose of the antibiotic daily for six days. The phagocytic activity was then measured on the eighth day by the rate of disappearance of a known amount of carbon from the circulating blood[5], the procedure being as follows. Each animal was given one intravenous injection of carbon of particle size 250 A., the dose of the carbon being calculated on the basis of 16 mgm. per 100 gm. body-weight. Blood was then taken at short intervals during the first 30 min. following the injection, and the concentration of the carbon in each blood sample was measured by an absorptiometer. The logarithmic values of the absorptiometer readings lie along a straight line when plotted against time, and the slope of the line has been taken as the measure of total body phagocytic activity or the phagocytic index, which is noted in the present communication by the symbol K.

Twenty-five of the animals were used as controls. They were given carbon only, and showed an average phagocytic index or K value of $18 \pm 5{\cdot}8$.

Fifteen types of antibiotic were investigated, some given orally and others parenterally. The results are shown in Table 1. Compared with the control values, it can be seen that the antibiotics used have little or no effect on the phagocytic activity of the reticulo-endothelial system. The low value shown for penethamate hydriodide is probably due to the toxic effect of this substance, since all the animals in this group showed general evidence of toxicity. The above results are at present being confirmed in a larger series of animals.

Table 1. Effect of Various Antibiotics on the Phagocytic Activity of the Reticulo-Endothelial System

Antibiotic used	Route of administration	Phagocytic index (K value)
Crystalline penicillin *G*	Subcutaneous	$27 \pm 2{\cdot}6$
Phenoxymethyl penicillin	Oral	$21 \pm 1{\cdot}6$
Benzathine penicillin	Oral	$16 \pm 6{\cdot}4$
Triplopen	Subcutaneous	$20 \pm 8{\cdot}5$
Dibenzyldipenicillin	Subcutaneous	12 ± 2
Penethamate hydriodide	Subcutaneous	$9 \pm 2{\cdot}4$
Chlortetracycline	Subcutaneous	$18 \pm 3{\cdot}0$
	Oral	$12 \pm 2{\cdot}8$
Tetracycline	Subcutaneous	$18 \pm 5{\cdot}6$
	Oral	$17 \pm 3{\cdot}2$
Oxytetracycline	Oral	$14 \pm 5{\cdot}1$
Dihydrostreptomycin sulphate	Subcutaneous	$13 \pm 3{\cdot}6$
Streptomycin sulphate	Subcutaneous	$13 \pm 2{\cdot}6$
Viomycin	Intraperitoneal	$15 \pm 3{\cdot}6$
Erythromycin	Oral	$16 \pm 2{\cdot}9$
Neomycin	Subcutaneous	$14 \pm 2{\cdot}8$
Chloramphenicol	Oral	$12 \pm 1{\cdot}6$
Control values in 25 animals	—	$18 \pm 5{\cdot}8$

In these investigations we gratefully acknowledge gifts of drugs from the Medical Directors of Messrs. Boots, Glaxo, Lederle, Eli Lilly, Parke Davis, Pfizer, Smith Kline and French and John Wyeth, and financial assistance from the Central Research Fund of the University of London.

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N-Terminal Histidine at the Active Centre of a Permeability Mechanism

The movement of glycerol across the membrane of the human erythrocyte is accelerated by a specific mechanism[1–3], one of the "facilitated diffusion" systems[3]. The activity of this mechanism has previously been considered to be dependent on the presence of the thiol group of cysteine[1]. I wish to report evidence suggesting rather that the residue concerned is histidine, situated in a particular position, namely, at the amino-end of a polypeptide chain.

The evidence arises from two types of experiments: studies of the inhibition of the facilitated diffusion system by heavy metals and by other chemical reagents; and direct isolation of the N-terminal histidine residue in such circumstances as to suggest that it has a role in the activity of the system.

The glycerol-facilitated diffusion system (or 'facilitator') is inhibited by traces (10^{-7} M) of copper[1], which is probably bound at or near the 'active centre' of the facilitator[3]. The association constant of the complex formed between copper and the group at the active centre has now been measured. The method used involved reversing the copper inhibition by adding a copper chelating agent of known dissociation constant. The value obtained (10^{19}) is close to that of the first-order association constant of the copper–histidine complex[4].

Histidine is considered to chelate copper through bonds with both the amino-group and the tertiary nitrogen of the imidazole ring[4]. Thus if a histidine residue in a polypeptide chain is to bind copper to the same degree as free histidine, it must have an available amino-group, that is, it must be situated at the amino-terminal end of the chain. Apart from cysteine, it can be predicted that all the other amino-acids, taken singly, in any position in the polypeptide chain, can bind copper at least a hundred times less readily than N-terminal histidine and could be readily distinguished from it by the method used here. Cysteine could be distinguished from N-terminal histidine by the use of mercurials. Thus, the inhibition of the facilitator by mercury can be reversed by histidine. Mercury may be expected to bind to thiol some 10^6 times as readily as to histidine, and histidine reversal of thiol blocking is thus improbable at the relative concentrations used here. Further, inhibition of the facilitator by *p*-chlormercuribenzoate is reversed by histidine, a result which would not be conceivable if thiol was the binding site for the mercurial, but would be predicted if, for example, the amino-group of histidine was concerned.

Finally, inhibition of the facilitator by *p*-chlormercuribenzoate was not found if the cells were suspended in the usual medium of buffered isotonic sodium chloride, but could be demonstrated if the suspension medium was isotonic sucrose[1]. Clearly, 0·17 *M* sodium chloride effectively reverses the mercurial inhibition (at 10^{-3} *M*). This again is understandable if the binding is at an amino-group but not if the binding site is a thiol residue.

The experimental observations, while consistent with the N-terminal histidine hypothesis, might be considered as being equally consistent with a pseudo-histidine structure composed of, for example, an imidazole residue from one amino-acid, together with an amino-group from its neighbour. Thus attempts at demonstrating that a true, integral N-terminal histidine residue is present at the active centre were initiated.

In the first place, the presence in the red cell membrane of N-terminal histidine was demonstrated by both of the end-group reagents commonly used: dinitrofluorbenzene[5] and phenylisothiocyanate[6]. Besides N-terminal histidine, at least two other N-terminal amino-acids were present (in concentrations some fifty times as great). These presumably arise from the other structural proteins of the stroma, but were not further investigated.

It remained to show that the N-terminal histidine isolated had in fact arisen from the glycerol facilitator and not from some other source. A structural analogue of glycerol, the glycol 1:3 dihydroxypropane, is a highly effective competitive inhibitor of the facilitator, with a Michaelis constant indicating a binding-power a hundred times as great as that of the substrate glycerol. (In the presence of this glycol the facilitator is not inhibited on reaction with the known inhibitor diazotized sulphanilic acid, a phenomenon analogous to the well-established cases of protection of enzymes by a substrate or competitive inhibitor.) If the reaction of red cell stroma with phenylisothiocyanate was performed in the presence of dihydroxypropane (1·25 *M*) little or none of the N-terminal histidine derivative could be isolated. However, the glycol did not prevent the reaction of the phenylisothiocyanate with the other terminal amino-groups of the cell stroma, or of another N-terminal protein containing histidine that we studied (gliadin). If the glycol-blocked stroma was washed free of glycol and treated again with phenylisothiocyanate, the terminal histidine derivative could be isolated. Thus the glycol specifically and reversibly prevents the reaction of the N-terminal histidyl residue. The most likely explanation of this phenomenon is that the glycol, acting as a competitive inhibitor, protects an N-terminal histidyl residue at the active centre against the action of the phenylisothiocyanate.

This work may give some understanding of the mechanism of action of the facilitator. It seems possible that a protein or polypeptide chain is involved, consistent with the view of the presence in the cell membrane of pores or plugs of protein which provide hydrogen-bonding pathways for molecules which penetrate by facilitated diffusion[3]. The capacity of imidazole for forming hydrogen-bonds and other stronger interactions with carbohydrates, and presumably glycerol, has been emphasized recently[7]. In particular, the physical situation of the histidine residue at the end of a polypeptide chain is likely to be of significance in the activity of the facilitator. Work is in progress in which the N-terminal histidine residue is used as a marker to monitor the isolation of the glycerol facilitator from the red cell membrane.

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Phosphorylation of Riboflavin by Transferase Action

When riboflavin is administered to the rat, a large amount of riboflavin is concentrated in the mucous membrane of the intestine, and an increase of flavin mononucleotide also occurs[1]. This result suggests that the administered riboflavin might be phosphorylated to flavin mononucleotide in the small intestine. As to the supposed mechanism of phosphorylation of riboflavin in this tissue, other than the action of flavokinase[2], the transferase action of phosphomonoesterase was examined.

Morton[3] described the transferase action of phosphomonoesterase which catalyses transphosphorylation from creatine phosphate to hexose. The present experiments indicate that phosphorylation of riboflavin can occur by the action of purified intestinal alkaline phosphomonoesterase with β-glycerophosphate as the phosphate donor.

A simplified procedure[4] for the purification of phosphomonoesterase from the mucous membrane of the intestinal canal was used. The mucous membrane of the small intestine of a dog was homogenized with 4 volumes of water, heated in a water-bath at 58° C. for 15 min. and then centrifuged at 7,000 r.p.m. for 20 min. at 0° C. The upper layer was frozen and stored for a day. After melting it, the resulting

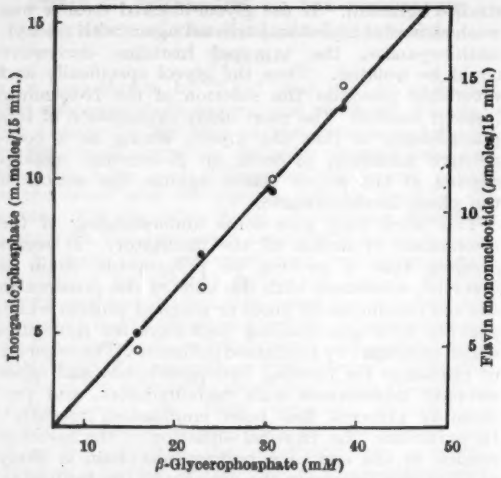

Fig. 1. Relation between the formation of flavin mononucleotide and the liberation of inorganic phosphate. ○, Flavin mononucleotide; ●, inorganic phosphate liberated. The reaction mixture (total volume, 1·3 ml.) contained riboflavin ($1·47 \times 10^{-4}$ *M*), β-glycerophosphate at the concentrations indicated, and purified intestinal alkaline phosphomonoesterase in veronal buffer (0·05 *M*) at *p*H 9·4, with magnesium (final concentration, 1 m*M*). The mixtures were incubated at 37° C. for 15 min.

precipitate was removed by centrifuging at 15,000 r.p.m. The upper layer was frozen again, and the same operation was repeated until a clear upper layer was obtained. This was saturated with ammonium sulphate, and the precipitate was dialysed against distilled water to remove ammonium sulphate completely. The dialysed solution was freeze-dried and the resulting white powder was suspended in distilled water. The supernatant was found to contain an active alkaline phosphomonoesterase by the test of substrate specificity and optimum *p*H. The activity was 200 times higher than that of the original homogenate.

For the synthesis of flavin mononucleotide from riboflavin by this phosphatase, the reaction mixture consisted of riboflavin, β-glycerophosphate and the purified phosphomonoesterase in veronal buffer (*p*H 9·4) with magnesium ions, as shown in Fig. 1.

After incubation for 15 min. at 37° C. in the dark, the inorganic phosphate liberated was estimated by the method of Fiske and Subbarow[5]. The flavins in the incubated reaction mixture were analysed by paper chromatography using several solvents[6], and the newly synthesized flavin mononucleotide was detected. After the flavins had been separated on the filter paper by using the mixture *n*-butanol/acetic acid/water (4 : 1 : 5 v/v, upper layer), the paper was dried, the part containing each flavin was cut out separately and extracted with water at 80° C. The molar ratio of flavin mononucleotide to the total flavin was measured fluorimetrically by a microphotofluorimeter[7].

As shown in Fig. 1, the rates of liberation of inorganic phosphate and of formation of flavin mononucleotide increased together as the concentration of β-glycerophosphate was raised. Moreover, phenyl phosphate or adenosine monophosphate could also be used as a donor of phosphate for the phosphorylation of riboflavin.

The optimum *p*H for the synthesis of flavin mononucleotide from riboflavin in this experiment was found to be 9·0–10·0. This is also the optimum *p*H range for the hydrolysing action of phosphomonoesterase. These observations suggest that the phosphorylation of riboflavin *in vivo* may be partly due to the transferase action of the phosphomonoesterase of the small intestine. This kind of phosphorylation mechanism may be of biological importance, for example, in coenzyme synthesis.

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Adenosine-5′-phosphates as the Stimulating Agent in Blood for inducing Gorging of the Mosquito

A mosquito can be fed to satiety either on blood or on a solution of sugar. It follows that both these afford acceptable stimulants by contact, though in dissimilar ways as their primary destinations are the midgut and the crop, respectively. Since so much is known about the chemoreception of insects, it is surprising that no convincing explanation has ever been given of the nature of the stimulation by blood. The present work on forcible feeding of *Culex pipiens* var. *pallens* Coquillett suggests that the stimulation is principally chemical and gustatory, and that its normal source is the adenosine-5′-phosphate of dietary blood cells.

A series of examinations was carried out to determine the effectiveness of various constituents of blood. Material to be tested was dissolved or suspended in a 0·15 *M* solution of sodium chloride, without addition of sugar, warmed to an initial temperature of 40–50° C. and offered from cotton-wool to female mosquitoes previously isolated in separate glass tubes. Washed ox-blood cells proved effective, whereas the plasma failed. Further analyses indicated that neither the particulate nature of the cells nor the presence of hæmoglobin was essential for eliciting the gorging response. Assuming that a certain factor was lost during the preparation of the substances, I attempted to extract an active principle from the blood cells with a mixture of ether–ethanol–water as solvent. The stimulant was separated by ion-exchange chromatography and ultimately identified spectroscopically as adenylic acid, which was estimated to be effective even at concentrations of 10^{-4}–10^{-5} *M*.

This result was readily confirmed with a pure commercial preparation of adenosine-5′-phosphoric acid, but it was not reproducible with hydrolysates of yeast pentose nucleic acid. Hence comparisons were made of the effectiveness of several compounds related to the nucleotide, each being dissolved in 0·15 *M* sodium chloride with *p*H adjusted to 7. Simultaneous feeding tests with the sodium salt of 5′-adenylic acid served as controls. As shown in Table 1, both the diphosphate and triphosphate of adenosine apparently produced a large proportion of positive responses; they were comparable in their effect to the monophosphate, though the net influence

Table 1. SUMMARY OF THE FEEDING TESTS WITH THREE CONCENTRATIONS OF NUCLEOTIDES AND RELATED COMPOUNDS

Compounds	No. of mosquitoes tested and No. satiated		
	10^{-3} *M*	10^{-4} *M*	10^{-5} *M*
D-Ribose	22 (0)	22 (0)	—
Adenine	22 (0)	22 (1)	—
Adenosine	39 (2)	39 (2)	14 (0)
Ribose-5-phosphate*	20 (1)	20 (0)	—
2′- or 3′-Adenylic acid	45 (3)	45 (1)	45 (0)
5′-Adenylic acid	50 (26)	475 (233)	435 (70)
Adenosine diphosphate†	—	50 (25)	50 (13)
Adenosine triphosphate‡	—	50 (18)	50 (6)
5′-Inosinic acid	20 (0)	20 (0)	20 (0)
5′-Guanylic acid	20 (0)	20 (0)	20 (1)
Theophylline ribose-5-phosphate	22 (0)	22 (0)	22 (0)
5′-Deoxyadenylic acid	20 (12)	40 (4)	40 (1)
5′-Deoxyguanylic acid	20 (3)	20 (1)	—
5′-Thymidylic acid	20 (0)	20 (0)	—
Riboflavine-5′-phosphate	20 (0)	20 (0)	3 (0)
Adenosine-5′-sulphate	25 (6)	25 (3)	25 (0)

* † Containing 1 and 6 per cent respectively of adenosine monophosphate.
‡ Containing 3 and 10 per cent respectively of adenosine mono- and di-phosphate.

of the triphosphate remained uncertain, owing to considerable contamination with diphosphate. Their decomposition during the tests was found to be negligible.

Table 1 also indicates some correlation between the effectiveness of the compounds and their structures. Both the nucleotide configuration and the adenine moiety are of fundamental importance. Conversion of adenosine-5′-phosphate to the sulphate or of its ribose to deoxyribose does not completely abolish the stimulating power, in strong contrast to the consequences of migration of the phosphate group from the 5′ position to the 2′ or 3′ position.

A fuller account of this work is being prepared.

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Participation of Reticulocyte Microsomes in the Incorporation of Iron into Hæmoglobin

IMMATURE rabbit erythrocytes (reticulocytes) have been found in several laboratories to be involved in the formation of hæmoglobin. This process was either measured directly by determining the increase in hæmoglobin[1] or through the incorporation of amino-acids into globin, glycine or iron into hæm. Following the kinetic evidence that the microsomes of intact reticulocytes participate in globin formation[2], we have attempted to study the steps of this synthesis with cell-free preparations. In this communication, we describe a role of the microsomes in what may be the final step in hæmoglobin formation—the insertion of iron.

Reticulocyte formation was stimulated in rabbits by daily intramuscular injection for one week of 1 ml. neutralized phenylhydrazine hydrochloride (2·5 per cent w/v) together with 50 μgm. folic acid and 0·05 μgm. vitamin B_{12}. Blood was obtained by heart puncture and cells were removed by centrifuging at 4° C. They were washed once with saline phosphate (isotonic sodium chloride with 0·001 *M* sodium phosphate, *p*H 7·2) and twice with isotonic sucrose. The reticulocytes were lysed with two volumes of glass-distilled water at 0° C. Microscopic examination indicated that cellular disruption was essentially complete within 5 min. A volume of 2 × isotonic sucrose (0·52 *M*) was then added to bring the lysate to tonicity, and any remaining intact cells and cell debris were removed by centrifuging at 4° C. for 20 min. at 1,300*g*. The supernatant fluid was carefully siphoned off and centrifuged at 100,000*g* for 30 min. in the 'Spinco' ultracentrifuge. The microsome pellet obtained was washed once by suspension in isotonic sucrose and centrifugation, and was then suspended in cold saline phosphate medium. The microsomal particles contained 40 per cent ribonucleic acid and were 20–25 mμ in diameter.

The incubation medium consisted of adenosine triphosphate 0·003 *M*, potassium phosphoglycerate 0·015 *M*, magnesium chloride 0·003 *M*, iron-59 in ferrous ammonium sulphate containing $1·5 \times 10^6$ counts per minute in 3·3 μgm. of iron, reticulocyte microsomes and extract in a total volume of 1 ml. The extract was prepared by freezing and thawing reticulocytes with an equal volume of isotonic saline phosphate and then removing all particulate matter by centrifugation at 100,000*g* for 1 hr. Incubations were performed at 37·5° C. for 15 min., the contents being then cooled in ice and the microsomes removed by centrifugation. To isolate hæmoglobin, the incubation medium, cleared of microsomes, was treated with carbon monoxide and chromatographed on 'Amberlite' *IRC*-50, *XE* 97 with 0·2 *M* sodium phosphate buffer, *p*H 6·5. The red band corresponding to hæmoglobin was dissected by hand from the extruded resin. After the protein of each fraction had been precipitated with trichloroacetic acid, it was washed and heated with a trichloroacetic acid–pyrophosphate mixture to remove non-hæm iron[3]. The washed residue was counted in centrifuge tubes with a well-type scintillation counter.

Table 1. INCORPORATION OF IRON-59 INTO RETICULOCYTE COMPONENTS

Experiment 1	Total radioactivity (counts/min.) in: Microsomes	Soluble fraction
Complete system	295 ± 24*	1,540 ± 20
Without adenosine triphosphate and phosphoglycerate	690 ± 36	948 ± 28
Without soluble extract	16 ± 4	8 ± 1†
With microsomes boiled	47 ± 3	14 ± 3

Experiment 2‡	Specific radioactivity (counts/min./mgm. protein): Microsomes	Soluble fraction	Hæmoglobin
Complete system	67 ± 7	35 ± 1	36
Without adenosine triphosphate and phosphoglycerate	106 ± 3	24 ± 1	25

* Standard error of the mean of duplicate incubations.
† Added after incubation to the medium at 0° C.
‡ In experiment 2 the microsomal protein weighed 5–7 mgm., the aliquot for counting the soluble protein, 7–12 mgm., and the isolated hæmoglobin 25–26 mgm.

Incorporation of iron required the presence of both the microsome and soluble fractions. Furthermore, as shown in Table 1, Exp. 1, microsomes which were boiled did not show this incorporation. It is also apparent from these results that in addition to iron incorporation into hæmoglobin, an extensive incorporation of iron occurs within the microsome itself, and that this also is completely dependent upon the presence of the soluble extract. The nature of the binding of this microsomal iron is at present not clear, but it would appear to be a hæmoglobin precursor. The results further suggest that the release of this precursor from the microsomes is stimulated

by the energy source, adenosine triphosphate and phosphoglycerate.

These observations do not appear to be in accord with recent suggestions by Eriksen[4], who incubated intact rabbit reticulocytes with acetate-2^{14}C and found that labelled microsomal hæm had the same specific activity as that in the soluble protein fraction. He suggested that this eliminated the possibility that microsomal hæm was a precursor of hæmoglobin. We have similarly found that hæm-protein, removed from the microsomal ribonucleoprotein with deoxycholate, had the same specific activity as that of the soluble protein after incubation of intact reticulocytes for short periods with leucine-^{14}C. It seems highly probable, therefore, that nearly all the hæm-protein on the microsomes becomes associated with these particles during isolation[5], and may obscure the presence of a smaller precursor fraction.

The results support the earlier observations of Walsh *et al.*[6] that the particulate matter of intact human reticulocytes incorporates iron, and suggest that this process is associated with the synthesis of hæmoglobin.

We wish to thank Prof. D. M. Greenberg for his continued interest in this work. The investigation was aided by a grant from the Cancer Research Funds of the University of California.

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Effect of Histamine and an Anti-Histaminic Drug on the Hæmolytic Action of Guinea Pig Complement

Cushman, Becker and Wirtz[1] have shown that the antihistaminic drug theophorin is a potent inhibitor of the hæmolytic action of complement. It is therefore of interest to study the effect of another antihistaminic drug and of histamine. Thenfadil (N : N-dimethyl-N′-2-pyridyl-N′-(3-thenyl)-ethylenediamine) was chosen for study[2]. In a preliminary experiment 0·012 *M* thenfadil inhibited hæmolysis by 56 per cent, while 0·010 *M* histamine inhibited it by 44 per cent. Inhibition in the presence of both compounds at these concentrations was 94 per cent. This suggested that both histamine and thenfadil can inhibit hæmolysis in a similar way. This inhibition was not due to increased concentration of salt[3], which, under the conditions of these experiments, had very much smaller effects. Further experiments were undertaken to determine the mechanism of inhibition by histamine and thenfadil, and thioglycollate, a known *C′*-inhibitor[1], was also tested. (Complement and its four components are designated *C′*, *C′*1, *C′*2, *C′*3, *C′*4, respectively.)

Mayer and his co-workers[4] have worked out the sequence in which the various components of complement react with sensitized erythrocytes to cause hæmolysis, so that it is possible to study some of the individual steps of this complex reaction series. Six reagents prepared from guinea pig serum are needed for this.

(1) Euglobulins prepared from serum treated with ammonia to inactivate *C′*4 [5] by dialysis against 0·019 *M* phosphate buffer, *p*H 5·4 [6]. This contains *C′*1. (2) The supernatant from the above dialysis, containing *C′*2 and *C′*3. (3) Euglobulins prepared from serum as in (1), except that no ammonia was used. This contains *C′*1 and *C′*4. (4) The supernatant from (3), containing *C′*2, *C′*3 and *C′*4. (5) Serum heated to 56° C. for 30 min., containing *C′*3 and *C′*4. (6) Serum treated with zymosan, containing *C′*1, *C′*2 and *C′*4. All reagents were made in, or diluted with, veronal–saline buffer containing magnesium and calcium ions[7].

Sensitized erythrocytes were treated with *C′*1 by incubating with (1) for 30 min. at 0° C. and then centrifuged. Resuspension in (2) + (5) and incubation for 15 min. at 37° C. allowed the complex EAC'_1 to react with the remaining components of the *C′* system (see line 1 in Table 1; *E* signifies erythrocyte, *A* is hæmolytic antibody and *EA* is therefore sensitized erythrocyte). A similar experiment, in which sensitized erythrocytes reacted successively with (3) and (4) + (5), separated the reactions of *C′*1 + *C′*4 with the cells from the reaction of $EAC'_{1,4}$ with *C′*2 + *C′*3 (see line 4 in Table 1). Finally, the complex $EAC'_{1,4,2}$ was prepared by the reaction of sensitized cells with (6) for 30 min. at 0° C. and treated for 15 min. at 37° C. with (5) as a source of *C′*3 to bring about hæmolysis (line 7 in Table 1). Each step was carried out both in the presence and in the absence of inhibitors. The results suggest that all the inhibitors studied act in at least two places in the sequence leading to hæmolysis. They inhibit the reaction of *C′*2 with the complex $EAC'_{1,4}$ and also the succeeding reaction of *C′*3 with the complex $EAC'_{1,4,2}$. Thenfadil and thioglycollate are stronger inhibitors than histamine. The compound lacking the thenyl group of thenfadil (N,N-dimethyl-N′-(2-pyridyl)-ethylenediamine) which has no anti-histaminic action, had no inhibitory action at concentrations of up to 0·02 *M*, and neither did histidine.

Table 1. Inhibition of Immune Hæmolysis by Incubation of Inhibitors with Various Intermediates

Complement and its four components are designated *C′*, *C′*1, *C′*2, *C′*3, *C′*4, respectively. *E* signifies erythrocyte; *A*, hæmolytic antibody and *EA* sensitized erythrocyte

Reaction studied	Histamine		Inhibitor Thenfadil		Thioglycollate	
	Molar concentration	Percentage inhibition	Molar concentration	Percentage inhibition	Molar concentration	Percentage inhibition
$EA + C'1 \rightarrow$	0·017	26	0·057	0	0·043	10
EAC'_1	0·023*	0				
$EAC'_1 + C'4 + C'2 + C'3 \rightarrow$ Hæmolysis	0·016	66	0·016	81	0·016	96
$EA + C'1 + C'4 \rightarrow$	0·024	36	0·024	0	0·033	0
$EAC'_{1,4}$	0·031*	0				
$EAC'_{1,4} + C'2 + C'3 \rightarrow$ Hæmolysis	0·017	76	0·017	73	0·025	96
$EA + C'1 + C'4 + C'2 \rightarrow EAC'_{1,4,2}$	0·016	46	0·016	82	0·016	78
$EAC'_{1,4,2} + C'3 \rightarrow$ Hæmolysis	0·016	32	0·016	72	0·016	87

* Added after the addition of euglobulins to sensitized cells. In all other cases the inhibitor was added to the cells before the reagents containing complement.

Histamine, however, has a further action which is not shared by the other inhibitors. If added to the reagents containing $C'1$ before the sensitized erythrocytes, it will inhibit the reaction between $C'1$ and cells. Histidine does not inhibit in these circumstances, nor is the inhibition influenced in any way by the addition of thenfadil. It is therefore probable that the reaction between $C'1$ and the sensitized erythrocytes involves a group with which histamine, but not thenfadil, reacts. A few experiments with β-phenylethylamine suggest that this compound weakly inhibits complement in the same manner as histamine. It would be of interest to study the effect of other naturally occurring aromatic amines such as tyramine, 5-hydroxy-tyramine and serotonin, for Cushman *et al.*[1] have shown that tryptamine is an inhibitor of immune hæmolysis.

The effects described here are unlikely to have any physiological significance, since the concentrations of histamine and thenfadil used to demonstrate inhibition are higher by several orders of magnitude than those likely to be encountered *in vivo*. However, they are of considerable interest from a pharmacological point of view because they occur in a relatively simple system in which histamine and an antagonist seem to react in a similar manner. While this behaviour is opposite to that usually observed *in vivo*, it may be of use in elucidating the mode of action of antihistaminic drugs, since the hæmolytic action of complement can be readily investigated *in vitro*. It will be of great interest to discover whether other antihistaminic drugs with structures different from that of thenfadil react similarly.

The study of the action of inhibitors on the various stages of immune hæmolysis may be of value in understanding the nature of the individual reactions and the functions of the components of complement. A search among other inhibitory compounds may reveal compounds each of which may inhibit the reaction of an individual component of complement with the sensitized erythrocyte-complement complexes.

I am grateful to Prof. F. Haurowitz for encouragement and much stimulating discussion, and to Dr. E. Campaigne for a gift of thenfadil and N : N-dimethyl-N′-(2-pyridyl)-ethylenediamine. This work was performed during leave of absence from the Medical College of St. Bartholomew's Hospital, London, and was supported by grants *G*-1296 of the National Science Foundation, Washington, D.C., and 1852-*C*(7) of the U.S. Public Health Service, Bethesda, Maryland, and by contracts of Indiana University with the U.S. Office of Naval Research (*NR*-120-035) and the U.S. Atomic Energy Commission, Washington, D.C. (*AT*-11-1-209).

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Immunological Estimation of a Component of Complement

Complement is normally estimated by the hæmolytic method, for which at least four components must be present : whichever is present in least relative amount controls the 'titre'. A simple method for estimating some or all of these components separately would be of value, particularly in clinical investigations. An immuno-diffusion method in agar[1] has been applied to the semi-quantitative estimation of one of these, probably C'_1, in human sera.

An antiserum was raised in the rabbit by the injection of an immune precipitate which had 'absorbed' complement from human serum. The precipitating system used was a rabbit-anti-potato protein and its homologous antigen : conditions were adjusted so that approximately 5 mgm. of antibody was precipitated in the presence of 9 ml. of fresh human serum. This precipitate was washed in physiological saline diluted 1 : 1 with water, made up in an adjuvant emulsion containing oil and dead tubercle bacilli, and injected subcutaneously in a rabbit. Three weeks later this injection was repeated : and after a further three weeks 60 ml. of blood was taken. This contained antibodies in high titre against one β-globulin component of human serum, and small amounts against another unidentified β-globulin, α_2-glycoprotein, and γ-globulin. (Diffusion lines produced by these minor antibodies do not usually interfere with the estimation, but attempts are being made to absorb them out.) Antibodies were also present against potato-proteins.

The β-globulin against which the bulk of the antibody was directed is apparently C'_1. The evidence for this (obtained by means of the gel-diffusion method quoted above, combined with standard hæmolytic methods) is as follows : (1) Separation from human serum of the euglobulin fraction by simple dialysis or by the more refined method of Pillemer *et al.*[2] led to an enrichment of the reacting substance ; the pseudoglobulin fraction (which contains C'_2 and C'_4) was correspondingly impoverished, although a little was still present. (2) Similarly, the fraction II.3 prepared by Cohn's method, which contains C'_1 (as well as the iso-agglutinins), contained this substance. (3) Zymosan absorption, sufficient to inactivate hæmolytic complement by removal of C'_3, had no effect upon this substance.

Heating serum to 56° C. for 30 min., which inactivates C'_1 in the hæmolytic test, had no obvious effect on the reacting substance : this is not altogether surprising since the enzymatic (esterase) activity of C'_1 might well be more labile than its serological reactivity.

C'_1 is known to be in excess in human sera ; therefore estimations by the two methods might not be correlated. However, in 24 cases in which parallel estimations have been done it can be seen that this correlation is surprisingly good (Fig. 1).

Nevertheless, two interesting discrepancies have been observed. (*a*) *Case Pr.* : A case of acute nephritis of fourteen days duration—at this time by the hæmolytic method of estimation total complement was nil, and our C'_1 estimation was 10 per cent of normal. Eleven and fourteen days later the former method still gave a negative result ; estimations of C'_1, however, were 75 and 100 per cent respectively. The deficient component in the last sample could be shown to be C'_3. These results incidentally indicate

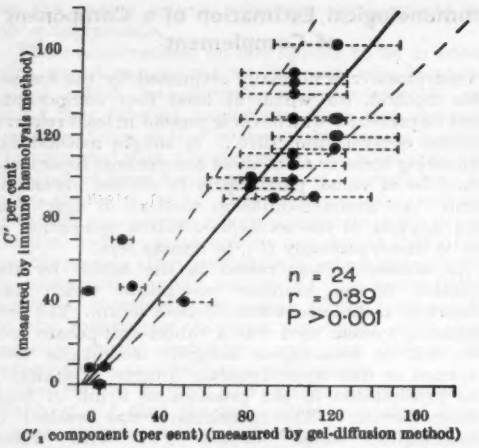

Fig. 1. Continuous line, calculated regression; interrupted lines, 25 per cent error limits; percentage values of arbitrary 'normal serum'

that, in this patient at least, the half-life of C'_1 was about four days. (*b*) *Case Rd*: A case of rheumatoid arthritis whose γ-globulin was 1·75 gm. per cent. Sera from such cases are often anti-complementary; the complement by the hæmolytic method was read as 9 per cent and the serum was shown to be moderately anti-complementary. The immuno-diffusion method, however, gave a reading of 100 per cent for C'_1. This result, in the only anti-complementary serum we have so far tested, suggests that a serological method may have some advantages in such circumstances.

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Prothoracic Glands in *Tenebrio molitor* L. (Coleoptera: Tenebrionidae)

Williams[1] was unable to locate prothoracic glands in the larvæ of Coleoptera, but later, Stellwaag-Kittler[2] claimed to have found them in *Tenebrio molitor*, and Núnez[3] described them in the carabid *Anisotarsus cupripennis*. In *Tenebrio*, Stellwaag-Kittler reported them as a pair of slender unbranched structures, each running anteriorly along a trachea from the prothoracic spiracle; on entering the head they converge, pass beneath the nerve cord and become attenuated. Closer examination of these relatively conspicuous structures in mature larvæ of *T. molitor* has now shown that each is continued anteriorly into a separate duct; the two ducts open separately, one on each side of the hypopharynx. In fact, these structures are evidently the 'salivary glands' which have previously been reported in some tenebrionid larvæ[4].

The true prothoracic glands of *T. molitor* are very small compact branched organs situated near the neck, where they lie a little behind the dorsal commissure, joining the paired dorsal tracheal trunks which run into the head from the prothoracic spiracles (Fig. 1). Because of their delicate, transparent appearance they are only seen after *intra vitam* staining with methylene blue. The fully developed prothoracic gland consists of a transverse band of cells which usually gives rise to a small anteriorly directed lobe and which enters into an association with the dorsal tracheal trunk. Medially, the transverse band is intimately attached to the branches of a conspicuous trachea given off laterally outwards by the ventral tracheal trunk. Running laterally, it spreads as a web between these fine tracheal branches and turns upwards to become associated with the dorsal trunk. From this point, it extends laterally again and ends indistinctly among fat body, muscles and tracheæ. The small spindle-shaped anterior lobe, which is sometimes absent, arises near the middle of the transverse band and is attached by its pointed end to a fine branch of the trachea arising from the ventral trunk. When well developed, cells of the gland may also spread as a thin sheath over the dorsal tracheal trunk, which then assumes a deeper colour in preparations vitally stained with methylene blue. The gland does not form an investment over the ventral tracheal trunk. Unlike the syncytial prothoracic glands described in most other insects, distinct cell-boundaries may be seen in *Tenebrio* and were also figured by Núnez in *Anisotarsus*.

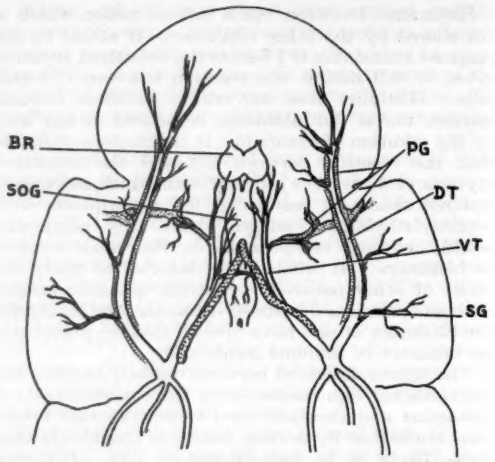

Fig. 1. Prothoracic glands of *T. molitor in situ* (dorsal view). *BR*, brain; *DT*, dorsal tracheal trunk; *PG*, prothoracic gland; *SG*, salivary gland; *SOG*, sub-œsophageal ganglion *VT*, ventral tracheal trunk

A study of the histological changes in these glands during the development of *T. molitor* is now in progress.

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Effect of Lime on the Production of a Toadstool (*Omphalia maura* (Fr.) Gill.)

In January 1956, as part of a wider series of experiments, a rectangular plot 10 yards × 20 yards was pegged out in each of three plantations of Scots fir (*Pinus sylvestris* L.), and dressed with lime at the

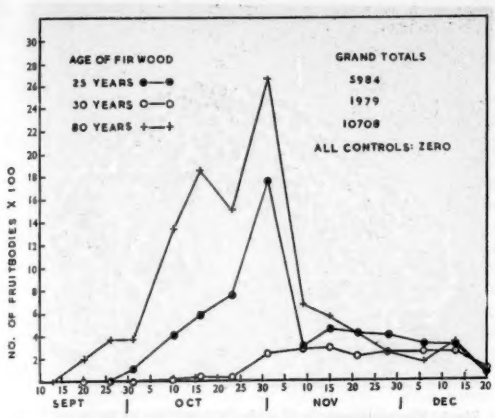

Fig. 1. Weekly counts of fruit-bodies of *Omphalia maura* on limed plots in three woods of *Pinus sylvestris*

rate of 0·81 ton per acre (2·03 metric tons per hectare). The firs are now about 25, 30 and 80 years old, are at the same altitude above sea-level (320 ft.) and are situated about 10 miles south-west of Reading. The soil, derived from Plateau Gravels which overlie Bagshot Sands, has a poor mineral status and is podsolized. The acidity is mostly in the range *p*H 3·5–4·5. Adjacent to each experimental plot, an exactly similar one was pegged out to act as a control, no treatment being given to it at all.

When the toadstool season began in 1956, each plot was visited weekly: all species were collected, named and then discarded outside the plots. *Omphalia maura* was found only on the limed plot of the 25-year-old plantation, the grand total for the season being 18 specimens. Not a single specimen was found on the control plot nor anywhere else on either of the other two plantations.

In the spring of 1957, the same experimental plots were again dressed with lime at the same rate and harvesting of toadstools took place as before. *Omphalia maura* occurred in all three plantations and the weekly counts are shown in Fig. 1 together with the grand totals for the season, namely, 5,984, 1,979 and 10,709 fruit-bodies for the 25, 30 and 80-year-old firwoods respectively. The species was again absent from all control plots and throughout the remainder of the plantations, nor did I see a single specimen anywhere else in the area. Differences in the grand totals of the three plantations are considerable and are reflected in the weekly counts, but I do not propose to discuss this here.

Omphalia maura is one of a number of fungus species which are almost confined to burnt ground (cf. ref. 1). Plant ash will, of course, raise the mineral status of the soil. When fresh, it contains more or less of the readily soluble potassium carbonate and, before the potassium is washed down, *p*H values of 10 or more are commonly encountered. Even where the potassium has been leached out, there still remain the relatively insoluble carbonates of calcium and magnesium which result in a *p*H of 8·5, or thereabouts, the same as that of a typical limestone soil. So far as my knowledge goes, *Omphalia maura* occurs on acid soils mostly in coniferous woods where there is gross contamination with ashes. I do not know of its occurrence on limestone soils, not even where there has been burning. These facts are consistent with the hypothesis that *Omphalia maura* is not so much a calcium-loving species as one which is encouraged by a sudden addition of alkali to the soil. Whether this is a distinct effect of the lime, or of any alkali, has still to be investigated.

The limed plots have also produced a few specimens of two other fungus species which favour burnt areas, namely, the Discomycetes *Galactinia praetervisa* (Bres.) Boud. and *Aleuria lilacina* Boud.

I shall be most grateful to receive any further information about the habitats of *Omphalia maura*, especially from abroad.

I wish to thank Prof. T. M. Harris for his help and encouragement at all stages of this work.

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Dihydrofolic Acid Reductase

The enzymatic reduction of dihydrofolic acid (FH_2) to tetrahydrofolic acid (FH_4) has been reported by several investigators[1–3]. Futterman[1] noted that dihydrofolic acid was reduced by chicken liver extracts when either reduced di- or tri-phosphopyridine nucleotide served as the co-factor. We have found that the rate of reduction of dihydrofolic acid by reduced diphosphopyridine nucleotide in the presence of a partially purified sheep liver preparation proceeds most favourably at *p*H values less than 5·5, whereas reduction by reduced triphosphopyridine nucleotide is favoured at *p*H values greater than 6 (Fig. 1). The possibility that two enzymes are involved in the reduction of dihydrofolic acid was tested by noting the effect of reduced triphosphopyridine nucleotide on dihydrofolic acid-reductase which had been saturated with reduced diphosphopyridine nucleotide at *p*H 5·7, a *p*H at which both nucleotides were found to be equally effective electron donors. No increase in activity was observed, suggesting that only one enzyme is involved in the reduction. Reduced diphosphopyridine nucleotide also had no effect upon dihydrofolic acid-reductase which had been saturated with reduced triphosphopyridine nucleotide.

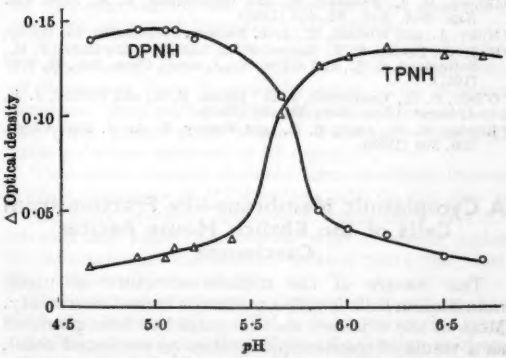

Fig. 1. *p*H activity curve of dihydrofolic acid-reductase. 15-min. incubations were carried out at room temperature in 1-cm. 'Corex' cuvettes. Cuvette contents: 3·0 ml. of 0·1 *M* sodium acetate buffer (*p*H 4·6–5·6) or 0·1 sodium phosphate buffer (*p*H 5·8–6·7), 0·06 μmole of dihydrofolic acid, 0·02 ml. of purified dihydrofolic acid-reductase and 0·3 μmole of reduced diphosphopyridine nucleotide (DPNH) ○, or reduced triphosphopyridine nucleotide (TPNH) △. Decrease in optical density was measured at 340 mμ

Osborn *et al.*[2] have also studied this enzyme system in chicken liver and have reported a Michaelis constant of $5 \cdot 0 \times 10^{-7}$ *M* for the substrate dihydrofolic acid when reduced triphosphopyridine nucleotide was employed as the co-factor and when the reaction was carried out at *p*H 7·5. We have determined the Michaelis constant for reduced diphosphopyridine nucleotide at *p*H 5·0, $K_m = 1 \cdot 5 \times 10^{-5}$ *M*, and for reduced triphosphopyridine nucleotide at *p*H 7·1, $K_m = 1 \cdot 0 \times 10^{-3}$ *M*. The values of K_m for dihydrofolic acid which we have found in this range of *p*H are $6 \cdot 2 \times 10^{-3}$ *M* (*p*H 5·0; reduced diphosphopyridine nucleotide as co-factor) and $1 \cdot 0 \times 10^{-5}$ *M* (*p*H 7·1; reduced triphosphopyridine nucleotide as co-factor).

Attempts at measuring the reverse reaction spectrophotometrically (di- or tri-phosphopyridine nucleotide reduction in the presence of tetrahydrofolic acid) have not been successful due primarily to the difficulty of stabilizing tetrahydrofolic acid in solution. Tetrahydrofolic acid was prepared by the method of May *et al.*[4] or O'Dell *et al.*[5] and, when freshly dissolved in buffers which were 0·02 *M* with respect to 2-mercaptoethanol, had an absorption maximum at about 300 mμ, which gradually (about 60 min.) shifted to about 280 mμ. The resulting material was slightly active as dihydrofolic acid in di- or tri-phosphopyridine nucleotide. Dihydrofolic acid was routinely prepared by the method of Futterman[1].

The purification of sheep liver dihydrofolic acid-reductase was similar to that described for the chicken liver enzyme by Futterman[1]. Ethanol fractionation was omitted and the calcium phosphate gel adsorption step was followed by adsorption and elution from sodium carboxymethyl-cellulose[6]. The purified dihydrofolic acid-reductase had only slight oxidizing activity to reduced di- or tri-phosphopyridine nucleotide in the absence of dihydrofolic acid.

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A Cytoplasmic Membrane-like Fraction from Cells of the Ehrlich Mouse Ascites Carcinoma

The nature of the surface structure of many mammalian cells is still a matter of some uncertainty. Most of the evidence on this point has been garnered as a result of microscopic studies on sectioned cells[1], except in the case of the erythrocyte; here, stromata can be prepared in quantity and studied by diverse means. To our knowledge, no isolations of analogous structures from other mammalian cells have been reported, although schemes for cell fractionation are available[2,3]. A search for methods of obtaining mammalian cell membranes in quantity is of importance, since availability would make possible a variety of studies which can be approached only by indirect means at present. This communication describes the isolation and partial characterization of a membranous, morphologically reproducible fraction from Ehrlich mouse ascites carcinoma cells.

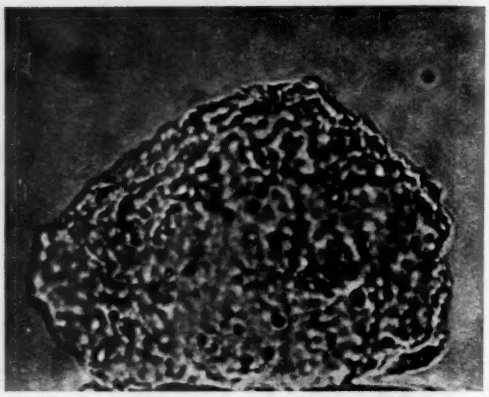

Fig. 1. Photomicrograph of a single membranous fragment from resuspended 'membrane' fraction. Note peripheral folds and presence of entrained granules. (× 970)

Pooled ascites fluid was removed from the peritoneal cavities of mice 6–7 days following inoculation with ascites tumour, delivered into chilled Alsever's solution, packed by centrifugation (35*g*, 0° C., 5 min.), washed free of erythrocyte contamination, and repacked. 1 ml. packed cells were suspended in 30 ml. of 0·9 per cent saline containing 0·01 *M* disodium ethylenediamine tetraacetate, *p*H 5·1, and disrupted in a Raytheon sonic disintegrator for 7 min. The lysate was allowed to sediment at 5° C., layered on sucrose solution (specific gravity 1·197) and centrifuged (1,100*g*, 0° C., 15 min.). 10-ml. portions of lysate were layered on 20 ml. of sucrose solution in 50-ml. centrifuge bottles for this purpose. Supernatant layers were discarded, the sediment suspended in 10 ml. of the ethylenediamine tetraacetate-saline solution, layered on sucrose, centrifuged as before, and the supernates discarded. Any loose powdery portion of the sediment was removed from the translucent sheet coating the bottom of the tube by repeated gentle agitation in small volumes of the saline solution. The remaining translucent material was resuspended in saline, resulting in a suspension of membrane-like fragments. Microscopic examination of suspended fragments showed sheets of membranous material which were thin, almost transparent, and having well-defined folds and edges (Fig. 1). The sheets carried variable amounts of granular material, which are thought to represent adsorbed intracellular material. Occasionally, fragments resembling individual stromata could be seen.

The washed 'membrane' fraction was suspended in saline and used for the intravenous immunization of rabbits, over a 4-week period. Blood serum from these rabbits was fractionated to yield γ_2-globulin by the method of Deutsch[4]. Part of the γ_2-globulin (which contains the majority of artificially stimulated antibodies) was reconstituted to original serum concentration, and titrated against the homologous 'membrane' antigen, against whole tumour cells and against an intracellular fraction prepared from whole tumour cells and consisting largely of mitochondria.

The quantitative 50 per cent end-point complement fixation test[5] was used for titration. Titres of 1 : 2,560 and 1 : 1,280 were obtained with whole cells and 'membrane' antigens respectively, and of 1 : 160 with the mitochondrial fraction. The remainder of the immune γ_2-globulin was conjugated with 1-dimethylaminonaphthalene-5-sulphonyl chloride by the method of Weber[6], freed of excess sulphonyl chloride by dialysis, and treated with whole tumour cells at 37° C. for 1 hr., with gentle agitation. The treated cells, washed free of unattached antibody at 5° C., were examined by ultra-violet microscopy, and were found to fluoresce strongly at a wave-length of about 350 mμ. Similar results were obtained when the 'membrane' fraction was used for the experiment.

The technical manipulations involved in the preparation of the 'membrane' fraction are unlikely to yield morphologically intact single membranes; rather, aggregates are to be expected. The membranous sheets obtained are believed to represent such aggregates. That this material is derived from the surface of the cell is suggested by the results of complement fixation tests and by studies with fluorescent antibody. Definite identification of the fraction as being composed of cell membranes is complicated by the fact that specific cytological criteria for these structures have not been placed on a firm basis, and must await considerable further study.

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Litters from *C3H* and *CBA* Ovaries orthotopically transplanted into Tolerant *A* Strain Mice

Used with conspicuous success in many fields of biological study, the general technique of transplantation has limitations which have gradually become clearer as the principles of transplantation immunity have been discovered. In general, it is now recognized that tissues can only be successfully transplanted from one individual to another if the host's tissues contain all the histocompatibility antigens possessed by the donor. This usually means that exchanges are most conveniently made between members of any one of the numerous inbred strains of mice which are available (isografts). It also implies that transfers between different inbred strains (homografts) will fail, a fact which accounts for the disappointing outcome of many experiments which require the growth of a tissue in a genetically foreign environment. The method for inducing tolerance of foreign tissues, developed by Medawar and his colleagues[1], now enables such immunological barriers to be overcome.

Fig. 1. The litter of seven pigmented offspring derived from mating a tolerant *A* strain female mouse carrying orthotopic transplants of *C3H* strain ovaries, with a normal *A* strain male

The following are details of experiments in which ovaries of one strain of mouse (either *C3H* or *CBA*) were transplanted orthotopically into a mouse of another strain (*A*) which had earlier been rendered tolerant to the *C3H* or *CBA* tissues. The grafted foreign ovaries became satisfactorily incorporated in the host and produced ova from which litters eventually developed.

In the first experiment an *A* strain female was injected intraperitoneally on the day of birth with 0·15 ml. of a spleen cell suspension from an adult *C3H* male mouse, in accordance with the technique described by Billingham and Brent[2]. When 66 days old, *C3H* skin was transplanted to the side of her chest so that there could be a visible indicator of the state of tolerance. Forty-four days later, when the skin graft still carried a good crop of agouti-coloured hairs, the host's ovaries were removed from within the ovarian capsules and replaced by ovaries from a 60-day-old *C3H* mouse. One week after the operation the tolerant *A* female was mated with a normal *A* strain male. This form of mating was decided on for the first two pregnancies to make sure that surgical removal of the host's ovaries had been complete. Offspring from any regenerated ovarian tissue would be non-pigmented, in contrast to the pigmented embryos expected from the *C3H* ovaries.

Four weeks after mating, the first litter of seven, all pigmented, was born (Fig. 1). The second litter of three was born four weeks later. The *A* strain male was then replaced by a normal *C3H* male, and the third litter of three pure *C3H* mice was born after a further interval of 27 days.

Two other tolerant *A* strain mice, similarly treated with suspensions of *CBA* spleen cells on the day of birth, have received orthotopic transplants of *CBA* ovaries and have been mated with *A* strain males. So far one mouse has had one litter of two; the other, two litters of one and five.

The success of these experiments opens up two fields for investigation. First, it confirms the practicability of studying the effects of a foreign environment on the behaviour, fertility and rate of ageing of ovaries of strains known to have widely differing properties from those possessed by the ovaries of the host strain. For example, the *C3H* and *CBA* strains lose their oocytes at the rate of about 25 per cent every 20 days, whereas the rate for the *A* strain is

only 10 per cent every 20 days. As a result, virtually all oocytes have disappeared from the ovaries of the *C3H* or *CBA* strains by the age of 450 days, when there are still about 500 in the ovaries of an *A* strain mouse. Transplantation from one strain to another should make it possible to determine the extent to which these differences depend on inherent differences in the ovaries, and how much on the environment, particularly the endocrine system and its secretions.

Second, it extends the scope of many experiments which hitherto have depended on and been limited by the technique of tubal transfer of ova. The successful transfer of an ovary of one genotype into the environment of another genotype should theoretically provide opportunities for the transformation of the genetic and cytoplasmic structure either of oocytes while they lie dormant in the early prophase stage of meiotic division or, if embryonic ovaries are used, of oogonia which are still dividing mitotically. *C3H* or *CBA* offspring born in this new way to *A* strain mothers will not only have been exposed to an *A* strain environment throughout intra-uterine life but also for any desired length of time while the primordial or developing oocytes remain within the grafted ovary.

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An Unstable Mutation in *Salmonella typhimurium*

Recently, Zamenhof *et al.*[1] described experiments which demonstrated the occurrence of pinpoint mutant colonies in *Escherichia coli*. These mutants arose in experiments in which 5-bromo-uracil was used as a mutagenic agent, and the pinpoint colonies were shown to be of three types: stable, unstable and very unstable. The unstable pinpoints were maintained for seven transfers, while the very unstable pinpoints were lost after only 12 hr. of growth.

I have recently demonstrated that similar unstable mutations occur spontaneously in *Salmonella typhimurium*. The mutations studied were from 'leucineless' to 'leucine independent'. It thus appears that the occurrence of unstable mutations in bacteria is not limited to *E. coli*, or to experiments in which a mutagenic agent is used.

In *S. typhimurium* mutations of 'leucineless' to 'leucine independent' are of three types distinguishable by their rate of growth on medium lacking leucine. The three types have been called 'fast', 'slow' and 'very slow'. The fast type grows to full colony size in 24 hr. (as does the wild type). The slow type shows barely visible growth after 24 hr. but has grown to full colony size after 48 hr. The very slow type shows barely visible growth after 48 hr. but has grown to a full-size colony after 72 hr. On medium containing leucine all three types reach full colony size after 24 hr. incubation.

The fast and slow types are both stable and can be transduced into the leucineless strain yielding only fast and slow transductional clones respectively. The very slow type is unstable in that it reverts spontaneously to leucineless at a very high rate. This instability is detected by shaking the clone to be tested in saline, diluting suitably, and spreading equal samples, each containing about 500 cells, on plates with and without leucine, and incubating the plates for 72 hr. The instability is then demonstrated first by there being fewer colonies on the plates without leucine than on those with leucine, and secondly those colonies which do develop on the plates without leucine show a gradation of sizes from minute to 4 mm. in diameter. All the colonies on the plates with leucine are of equal size.

Very slow clones arising from independent mutations show varying degrees of instability. One clone was shaken in saline and plated on medium lacking leucine. All the colonies that grew were very slow. Eight of these colonies were shaken in saline and samples plated on medium with leucine and on medium without leucine. It was found that all eight colonies contained 1–20 per cent of very slow cells (80–99 per cent leucineless cells). From a similar experiment on a different clone twenty colonies were shown to contain 0–0·2 per cent of very slow cells (99·8–100 per cent leucineless cells).

The fast type is probably a true back-mutation of leucineless to wild type; the slow type may be due to a suppressor mutation or to a mutation to a different allele at the leucine locus.

Further experiments are in progress to determine whether the instability is confined to the leucine locus, and whether a leucineless strain obtained from the very slow type shows any residual instability.

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Effects of Gibberellic Acid on *Nicotiana* Plants

The physiological action and practical application of gibberellic acid are well known (H. Seltman, private communication and refs. 1 and 2). Tests were conducted to investigate its possible application to the control of the alkaloid content and plant development of different *Nicotiana* species. Gibberellic acid was supplied by Eli Lilly and Co. and Merck and Co.

Seedling survival and new growth. Gibberellic acid was tested to see whether it can help tobacco seedlings to overcome the shock immediately following transplanting to the field and thus improve survival of seedlings and stimulate earlier growth. Immersion of the root in 10 p.p.m. gibberellic acid for 10 min. before transplanting, or spraying with 1 p.p.m. gibberellic acid on the leaves after transplanting to the field had no observable effect.

Shoot development. N. tabacum var. Robinson and var. Maryland Mammoth, *N. tomentosa*, *N. tomentosiformis*, *N. otophora* and *N. wigandioides* were employed to study the effects of gibberellic acid on the development of leaf, stem and flower. Five of these plants were each given six applications of 15 μgm. gibberellic acid by injection with a hypodermic needle near the growing point at weekly intervals beginning two weeks after transplanting. At 10 weeks the treated plants were approximately one-third taller than the five controls, due to an

increase in internodal length. By the end of the season, however, size differences between treated and control plants were less noticeable. The leaves on treated plants were longer, narrower, curled at the margins, and subject to sun-scalding at the tips. Flowering was not affected.

Alkaloids. Several tests, using solution and soil culture along with different rates and methods of application of gibberellic acid, were conducted in the greenhouse using 4–6 plants in each treatment. The summarized results are as follows:

(*a*) Gibberellic acid was applied to the leaves of *N. tabacum* var. Robinson and *N. rustica* var. brasilia plants. The amounts were (1) 0; (2) 0·05; (3) 5; and (4) 10 μgm. applied as a drop of water solution on the leaf surface at 3-day intervals for a period of 3 weeks. Plants were harvested 2 weeks after the last application. The relative proportions of alkaloid yield per plant were (1) 100, (2) 89, (3) 63 and (4) 55, respectively. On tobacco plants which were topped and suckered and therefore of increased alkaloid content, the relative effect of gibberellic acid remained the same. Plants treated only once with 10 μgm. gibberellic acid on the leaf contained 95 per cent as much alkaloid as the control 5 weeks later.

(*b*) Gibberellic acid was applied to *N. tabacum* var. Conn. broadleaf and *N. rustica* var. brasilia by growing plants in nutrient solution containing gibberellic acid as follows: (1) 0 p.p.m.; (2) 1 p.p.m.; (3) immersion of root in a solution containing 10 p.p.m. gibberellic acid for 10 min. followed by growth in nutrient solution without additional gibberellic acid. After 4 weeks the relative alkaloid contents were (1) 100; (2) 23; and (3) 93, respectively. In another test, the roots of Robinson tobacco plants were immersed in a solution containing 10 p.p.m. gibberellic acid for 10 min. and then transplanted into 7-in. pots of soil. The alkaloid content was 94 per cent of that for the control after 4 weeks.

(*c*) Combined treatment was used consisting of 10 μgm. gibberellic acid on the leaf and immersion of the root in 10 p.p.m. gibberellic acid for 10 min. before transplanting to 7-in. pots. The alkaloid content was 61 per cent of that for the control after 4 weeks.

The intensity of effect increased with the amount of gibberellic acid applied, and the alkaloid content decreased. However, no change in the composition of the alkaloids was observed in any of these tests.

Induction of flowering. Four plants of each of the following *Nicotiana* species were grown in the greenhouse: *N. repanda*, *N. alata*, *N. bonariensis*, *N. longiflora* var. grandifolia, *N. longiflora* var. brevifolia, and *N. angustifolia* characterized by a basal rosette, and *N. knightiana*, *N. arentsii*, *N. eastii*, *N. benavidesii*, and *N. miersii* which did not form a rosette (*N. angustifolia* is a deviant form probably related to *N. bonariensis*.)

Two plants of each species were treated with 1 μgm. gibberellic acid every 2 weeks by applying as a drop of aqueous solution to the growing point or centre of the rosette. Generally, gibberellic acid did not affect flowering of the non-rosette *Nicotiana* species, but was effective in inducing earlier flowering of the rosette-type species, which are long-day plants[1]. *N. repanda*, treated in the autumn, flowered in 5 weeks, while controls flowered 2 months later. In early spring, plants of *N. longiflora* var. grandifolia and var. brevifolia flowered 12 days after the first treatment, in comparison with 23 days for the controls. Treated plants of *N. alata* flowered 7 days ahead of the control. *N. bonariensis* and *N. angustifolia* initiated flowers 4 weeks after treatment, whereas the controls were still in the rosette stage. The control of time of flowering of rosette species by means of gibberellic acid may be helpful in interspecific breeding.

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Evolution of Sex in the Flowering Plants of South Australia

Lewis[1] classified the English flora according to the frequency and distribution of sex forms in the species, genera and families. There are three basic sex forms in flowering plants and some species may be combinations of more than one of the three. Most flowering plants are hermaphrodite, having both sexes in the same flower. A species which has separate male and female flowers on the same plant is monoecious, and a species with male and female flowers on different individuals is dioecious. Using Black's flora[2], the species of the South Australian flora are classified into these sex forms in Table 1.

Table 1. Distribution of Sex Forms in the Species of the South Australian and English Floras

Sex form	No. of species (with percentages in brackets) in: South Australian flora Introduced		South Australian flora Indigenous		English flora	
Hermaphrodite	445	(92·0)	1,871	(88·9)	2,080	(92·2)
Monoecious	33	(6·8)	123	(5·8)	122	(5·4)
Dioecious	3	(0·6)	88	(3·9)	54	(2·4)
Mixed	3	(0·6)	20	(1·4)	–	(–)
Total	484	(100)	2,102	(100)	2,256	(100)

Comparing the three forms of species of the indigenous South Australian flora with the English flora gave a $\chi^2_2 = 12{\cdot}24$ ($P < 0{\cdot}01$). This level of significance is mainly due to a greater proportion of dioecy in the South Australian flora.

As in the English flora, dioecy is rare but widespread, and occurs in 16 families (17 per cent of the total), being particularly common in the Chenopodiaceae, Euphorbiaceae, Sapindaceae, Restionaceae and Liliaceae. These results support Lewis's suggestions that dioecy evolved from hermaphroditism. Monoecy is scattered throughout many families and, presumably, it too has evolved from hermaphroditism. Furthermore, as in the English flora[1], there is an association between monoecy and dioecy. The difference between the two floras is probably environmental, as the climates of South Australia and England differ greatly.

The flora introduced since the arrival of the White man shows some striking contrasts when compared with the indigenous flora. Very few dioecious species are recorded, probably because of the relative difficulty of introducing species which require two

separate plants. The proportion of monoecious species is, however, the same as that in the English flora. Dioecy thus appears to be a property of an old and fairly static flora, and in the South Australian introduced flora dioecy has not yet become well established. At present there are 1·7 species per genus in the introduced flora and 3·7 in the indigenous flora of South Australia, and 4·3 in the English flora[1], but the number of genera per family is approximately the same in all three (4·9–5·9). In the future, the entire flora of South Australia will probably become equivalent to the English flora in sex distribution, which has been shown[1] to be similar to that of the world flora[2].

In general, Lewis's[1] main conclusions hold. The results support the evolution of dioecy from hermaphroditism and monoecy, and also the association of dioecy with monoecy.

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Species Hybrids of Tea

Wight and Barua[1] have shown that pellucid punctations of leaves, caused by sclereids, indicate species hybrids of tea (*Camellia sinensis* L.). On this criterion certain cultivated tea populations popularly known as China hybrid are supposed to have had either *Camellia irrawadiensis* (P. K. Barua) or another similarly punctate *Camellia* as one possible progenitor.

A chromatogram for phenolic constituents of *C. irrawadiensis* shows a characteristic spot which at once distinguishes it from a chromatagram of *C. sinensis*[2], while chromatograms of a punctate F_1 hybrid between *C. irrawadiensis* and *C. sinensis* var. *assamica* (Masters) show spots characteristic of both parents. When one plant of this hybrid was crossed with a plant of chance origin supposedly 'hybrid' for the features of the southern form[1,2] and the China variety (*C. sinensis* var. *sinensis*), then the progeny were punctate but did not show the chromatogram spots characteristic of *C. irrawadiensis*; nor are such spots shown in chromatograms of the punctate plants known as China hybrid. It seems, therefore, that chromatograms which show spots characteristic of both *C. sinensis* and *C. irrawadiensis* are indicative of comparatively simple crosses between the two species; and more complex crosses, indicated by sclereids, may fail to show spots characteristic of *C. irrawadiensis*.

Chromatographic evidence of chance hybrids between *C. irrawadiensis* and the tea plant has been obtained from Kingdon-Ward's No. 22839 in Herbarium I.T.A., collected on our behalf in the region of Mount Victoria (Kanpetlet), 6,500 ft. (21° N., 94° E.), Burma. These plants are said to have been introduced, presumably as tea, from the Shan States about the first decade of the present century.

Table 2. Unidentified Phenols and Flavonols

Origin of sample	*UPa*	*UPb*	*UPc*	*UFa*	*UFb*
C. sinensis, southern form	(+)	—	—	—	—
C. sinensis var. *assamica*	—	—	—	—	—
C. irrawadiensis (9/5)	Trace	(+)	Trace	—	—
Experimental hybrid (8/6 × 9/5)	Trace	+	(+)	—	—
Experimental hybrid (28/1 × 9/5)	Trace	++	+	(+)	(+)
Experimental hybrid (3/191 × 9/5)	Trace	+	(+)	(+)	(+)
Plant K.-W. 22839	(+)	++	(+)	+	+

Kingdon-Ward's No. 22839 is a plant with stigmas and anthers characteristic of *C. irrawadiensis*; the leaves are similarly cuneate at the base, and equally densely punctate. In size and texture the leaves are similar to those of *C. sinensis* var. *assamica*. The flowers are small like those of tea, but the leaf sclereids are uniform and typical of *C. irrawadiensis*; whereas those of our experimental hybrids were of mixed characteristics in the same plant.

The situation was made much clearer by paper chromatography of Kingdon-Ward's plant. Chromatograms for phenolic constituents were run according to the methods described by Roberts *et al.*[2]; in all cases the same volume of a standard methanolic extract was applied to the paper.

Kingdon-Ward's plant closely resembles, chromatographically, three separate F_1 populations raised by crossing *C. sinensis* var. *assamica* with *C. irrawadiensis*. Tables 1 and 2 compare the strengths of certain phenolics. In Table 1 Kingdon-Ward's plant is shown to differ from *C. irrawadiensis* in its catechin pattern and from tea in possessing substance *A*, and to be intermediate between the two in respect of ellagic acid. In Table 2 it resembles the F_1 hybrids in possessing certain unidentified substances not reported by Roberts *et al.*[2]. *UPa*, *b* and *c* are three phenols occurring close to myricetin glucoside; they react with the ferric chloride–potassium ferricyanide reagent of Kirby, Knowles and White[3], and also with ferric alum (blue-black), but not with vanillin. *UFa* and *UFb* are two flavonol glycosides occurring between substance *IC* and theogallin. In addition to the substances in Tables 1 and 2, Kingdon-Ward's plant resembles the F_1 hybrids in possessing all the usual phenolics of tea; it lacks the rhamnodiglucosides of quercetin and kaempferol characteristic of the China variety of *C. sinensis*[2].

Kingdon-Ward's plant should be placed as a hybrid between *C. irrawadiensis* and *C. sinensis* var. *assamica*, with many features of the former. The holotype of *C. irrawadiensis* was raised from seed believed[4] to have been collected between 26–27° N.

Table 1. Major Phenolic Constituents

Origin of sample	Substance *A*	Substance *IC*	*epi*Gallocatechin	*epi*Catechin	*epi*Gallocatechin gallate	*epi*Catechin gallate	Ellagic acid
C. sinensis, southern form	−	++	++	+	++++	+++	(+)
C. sinensis var. *assamica*	−	−	++	+	++++	+++	(+)
C. irrawadiensis (9/5)	++++	+	−	−	+	+(+)	++
Experimental hybrid (8/6 × 9/5)	+++	+	+	(+)	+++	+++	+
Experimental hybrid (28/1 × 9/5)	+++	+	++	+	+++	+++	+
Experimental hybrid (3/191 × 9/5)	+++	+	++	+	+++	+++	+
Plant K.-W. 22839	+++	++	+(+)	+(+)	+++	+++	+

Intensities of spots are indicated by the scale ++++ very strong to (+) very weak

and 98–99° E. Another specimen, incomplete and supposedly conspecific, was collected in the Kachin Hills, Upper Burma (Indian Botanic Garden Herbarium No. 50243) by Shaik Mokim[4]. Kingdon-Ward's No. 22839 suggests that *C. irrawadiensis* exists in pure form in the Shan States, and that uncontrolled crossing occurs between that species and *C. sinensis*.

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Indian Tea Association,
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Cinnamara, Assam.
Feb. 18.

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Fumigation under a Polyethylene Envelope

Protection of bagged grain in storage from loss through insect attack has been the subject of much practical work in recent years. A method now widely accepted is stack fumigation with methyl bromide under gas-proof sheets, combined with a treatment of the outside of the bags with an insecticidal dust or spray. In a warm climate such as Kenya's the insecticidal treatment does not 'seal' the stack from re-infestation, and a second fumigation is often needed after only three months. The new method under trial involves the sealing of stacks with a polyethylene cover which costs no more than paper, and the investigation of fumigating with methyl bromide under such a gas-permeable covering.

Polyethylene liners are employed to seal the bagging used for numerous products. The polyethylene generally employed is 2/1,000 in. thick and has been found to be sufficiently permeable to permit an initial sterilizing fumigation (Turtle, E. E., personal communication and ref. 1), yet to serve as a good seal against re-infestation. On a very small scale, stack sealing has been attempted at the Pest Infestation Laboratory, Slough[2]. A few bags were 'cocooned' with a sprayed polyvinyl plastic so as to initiate self-sterilization (due to oxygen depletion by the enclosed insects) and to create a seal against re-infestation.

A large-scale experiment has been carried out here, after consultation with officers of the Pest Infestation Laboratory, Slough, on stacks of 200-pound bags of maize 20 ft. by 20 ft. by 15 ft. high. One of these stacks was completely enclosed in 2·5/1,000-in. polyethylene, and was fumigated at the same time as an identical stack covered with gas-proof 'Neoprene' on nylon sheets. This control stack had the sheets removed after 48 hr. Gas samples were drawn from several sampling points, and the analyses for methyl bromide were done by Volhard's titration. Table 1 shows the typical results from one sampling point near the heart of each stack. Also in Table 1 are the concentration by time ($c \times t$) products estimated from the curves which are shown in Fig. 1. The initial difference in the levels of concentration has no relevance; in the first hours the distribution of gas was variable due to slight differences in the release of the gas, but both stacks received the same quantity of fumigant.

Table 1. Concentrations and the Times of Sampling for one Location, and the Resultant $c \times t$ Products

Location of samples	Concentration of methyl bromide in oz. per 1,000 ft.³ (or mgm./l.) at sampling times in hr. after gas release:								$c \times t$ products	
	¾	1¾	5¾	10¾	23¾	47¾	51¾	71	After 48 hr.	After 96 hr.
Control stack	1·4	6·4	9·8	8·7	10·7	5·8	3·4	0·5	415	440
Polyethylene stack	11·0	13·8	10·0	10·1	7·9	4·4	4·0	2·4	390	490

In the 48–96-hr. period, the gas distribution was found to be uniform throughout the stack. The continuation of the fumigation indefinitely is therefore of great advantage, for a considerable general increase in the $c \times t$ product will result. Considering the estimated 96 hr. $c \times t$ product, the polyethylene-covered stack gave superior results. The losses through the polyethylene are restricted to loss by diffusion: consequently, if the stack were increased in size the losses would be of even less significance. After 48 hr. most of the gas has been sorbed by the product, and the danger in entering the store after 72 or 96 hr. is negligible. When all the gas has been sorbed and broken down chemically, the bromine content in the product is still well below a toxic level.

In practice we believe that the use of the much stronger (5/1,000-in.), polyethylene and 'sand-snakes' to hold the envelope to the floor, together with a seal against re-infestation in the form of a heavy strip of insecticidal dust around the edge of the stack, will result in complete protection of the grain. Great economies should be possible since the cost of additional fumigations will be eliminated, insecticide costs will be negligible, and the capital cost of expensive fumigation sheets will not be incurred.

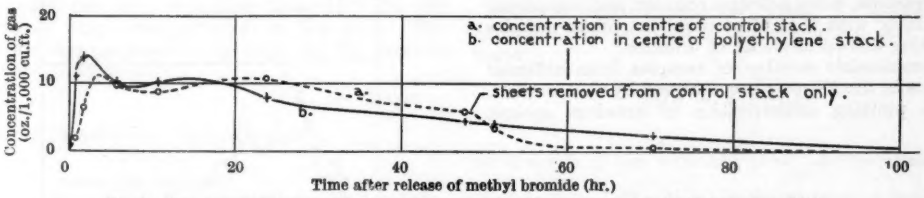

Fig. 1. Gas concentration curves for stacks: normally sheeted (*a*), and polyethylene covered (*b*)

The study is being continued, and a detailed report will be published elsewhere.

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Scott Agricultural Laboratories,
Nairobi, Kenya. April 12.

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Minor Constituents and Trace Elements in Negev Phosphate Rocks

In the course of research on Negev phosphate rock, attention was directed to the presence of minor constituents and trace elements in the rock.

The analytical work involved in identifying these was considerable, as many of the methods in general use are not applicable when large amounts of phosphate ions are present. Even if the phosphate does not interfere, trace elements are sometimes present in amounts smaller than those required for detection by standard methods, and very often laborious separations were necessary in order to obtain the element in the pure form required for analysis.

Qualitative spectrographic analysis has revealed the presence of the following elements: aluminium, silver, arsenic, barium, calcium, cadmium, chromium, copper, iron, fluorine, potassium, magnesium, manganese, sodium, nickel, lead, titanium, uranium, vanadium and zinc.

Most of the elements detected by spectrographic analysis or by other means were determined quantitatively. Results were as follows (per cent): aluminium, 0·1; arsenic-203, 0·002–0·004; chlorine, 0·09–1·3; chromium, 0·015–0·05; copper, 0·0005; iron, 0·3–1·5; magnesium, 0·3; nickel, 0·003; lead, 0·0005; silica, 0·1–0·8; sulphate, 0·06–0·3; sulphide, 0·012–0·016; titanium monoxide, 0·06–0·16; uranium, 0·005–0·015; vanadium, 0·03; zinc, 0·0005; and organic matter, 0·1–0·7.

These results are in very good agreement with the results reported by Hill, Marshall and Jacob[1] from a survey analysis of minor metallic constituents of many phosphate rock samples originating from various areas in the United States.

Uranium was determined fluorometrically by the method of Price, Ferretti and Schwartz[2] and by that of Yeaman[3]. The uranium content of Negev phosphate rocks is almost identical with that of phosphorites from Algeria, Tunisia and Egypt: 0·004–0·016 per cent as reported by Davidson and Atkin[4]. Florida phosphates, as reported by the latter authors, may have a considerably higher uranium concentration, 0·001–0·15 per cent. Phosphorite from Morocco contains, according to Lenoble[5], 0·01–0·06 per cent uranium.

Uranium has also been determined by β-activity measurements, using a Geiger counter, and comparing the activity with that of calcium phosphate samples containing known amounts of uranium.

A considerable number of samples from different locations in the Negev were analysed by this method, and on plotting concentration of uranium against concentration of phosphate (Fig. 1) a direct relationship was found between the two. This is in partial agreement with the data given by Thompson[6] in his paper on distribution of uranium in rich phosphate beds of the phosphoria formation. The latter, however, found a poor uranium–phosphate correlation in samples containing smaller amounts of uranium, while our results show good correlation in the low concentration zone as well. This is probably due to the lower concentration of organic matter in our samples.

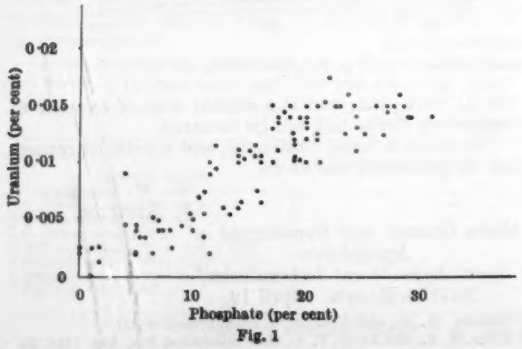

Fig. 1

Thanks are due to Dr. M. Berl (Research Department of the Ministry of Defence), who made most of the chemical determinations, and to Mrs. I. Leviatan (Israel Atomic Energy Commission) for carrying out spectrographic determinations.

E. Foa

Israel Atomic Energy Commission.

April 8.

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Duration and Band-width of Short-lived Transients in Solar Noise

The duration of small bursts in solar radio noise at 400 Mc./s. has been stated[1] recently to be 0·18 ± 0·03 sec. This value was a maximum in a histogram. On days with an intense small-scale activity, the material obtained is so abundant that reliable histograms can be obtained for periods as short as two hours. Fig. 1 shows an example of such a set. The shift of the maximum and of the entire curve is undoubtedly significant in most cases, and it should be possible to correlate it with a similar shift in the circumstances in which the bursts originate.

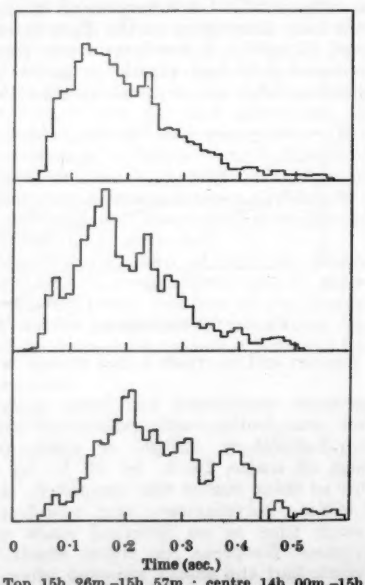

Fig. 1. Top, 15h. 26m.–15h. 57m.; centre, 14h. 00m.–15h. 19m.; bottom, 11h. 00m.–12h. 24m.

Table 1

Channel distance (Mc./s.)	1·5	2	2	3	4	4	4·5	6	8	9	9	10	11·5	12
No. of bursts	33	256	255	113	149	148	48	13	79	56	30	332	153	89
Band-width (Mc./s.)	11·5	15	12	18	14	10	13	10	9·5	15	8	13	15	20

After the single-frequency measurements had yielded enough data for a statistically sound reduction, a two-channel receiver was built, covering the band 394–406 Mc./s. One channel is fixed at 394 Mc./s., the other is tunable to any frequency in the band. The outputs are recorded on a two-pen moving-coil instrument with a response time of about 0·01 sec. The noise figure of the receiver varies between 3 and 4 over the band and the intermediate-frequency bandwidth of each channel is 1 Mc./s. Bursts with an intensity of a few per cent of the quiet level can still be distinguished unambiguously from inherent noise and interference.

The following parameters are used to determine the half power band-width of the average frequency profile of small bursts from records obtained at a certain channel distance: (*a*) the mean ratio of the intensities of a burst in the two channels, individual ratios always being taken as less than one; (*b*) the mean intensity; intensities less than (*c*), a threshold value necessary for theoretical and practical reasons, are excluded. These parameters determine the width of a theoretical profile when the phenomenon is randomly distributed in the frequency region of interest. This requirement has been met by rejecting the few samples which showed a significant difference between mean intensities of bursts in the two channels. Table 1 shows some results when a Gauss profile is adopted; other profiles give rise to slightly different values. The weighted mean is $13{\cdot}6 \pm 2{\cdot}6$ Mc./s. De Jager and van 't Veer[2] suggested a band-width of 6 Mc./s. at 200 Mc./s., from material obtained at two fixed frequencies 5 Mc./s. apart.

Clearly this is an over-simplification, and accordingly the result is only preliminary. It would be very useful to repeat these observations with a multi-channel receiver (which is now being constructed).

With the equipment used here, it is still possible to determine time differences of 0·02 sec. between events in the two channels. No cases have been noted of small bursts occurring at two frequencies in the band at times differing more than this.

This work has been supported financially by the Netherlands Organization for Pure Research. My thanks are due to Mr. J. T. de Jager for the prompt supply of a good receiver.

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[1] de Groot, T., *Nature*, **180**, 382 (1957).
[2] de Jager, C., and van 't Veer, F., I.A.U. Symposium No. 4 on Radio Astronomy, 1957, Paper 70, Commun. Acad., Amsterdam (1958).
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A Statistical Model of Some Time Series

THE behaviour of Hurst's[1] range R is incompletely known, but it is evidently closely related to the standard deviation of the sum of N successive quantities, since the sums used in finding R are highly correlated. In fact, for a large number N of independent quantities, of standard deviation σ, $R \propto \sigma\sqrt{N}$. If the quantities are correlated:

$$R \propto \sigma N\sqrt{u(N)}, \quad N \text{ large}$$

where $\sigma^2 u(N)$ is the variance of mean of N successive quantities. If N is large the effect of differences between deviations from the measured mean and deviations from the true mean becomes small.

If $F(t)$ is a continuous function of time, without periodic terms, and with long-term mean zero and standard deviation σ, autocorrelation $r(t)$ and power spectrum $w(f)$; then:

$$u(t) = \frac{2}{t^2}\int_0^t (t-x)r(x)\mathrm{d}x,$$

and from Rice's relations[2]:

$$u(t) = \frac{1}{2\pi^2 t^2\sigma^2}\int_0^\infty \frac{w(f)(1-\cos 2\pi ft)}{f^2}\,\mathrm{d}f$$

If $w(f) \propto f^x$, f small ($x > -1$ if the variance is to be finite), and $u(t) \propto t^y$, t large, this expression gives:

$$\begin{array}{lll} -1 < x < +1 & y = -1 - x \\ x = +1 & u(t) \propto \log t/t^2 \\ x > +1 & y = -2 \end{array}$$

The case $x = 0$, $w(0)$ finite, is usually regarded as the 'ordinary' case, where $u(t) \propto 1/t$ in the limit. Exceptionally stable functions, such as the time derivative of an 'ordinary' function (where $x = +2$), have

$$u(t) = \frac{1}{2\pi^2 t^2\sigma^2}\int_0^\infty \frac{w(f)\mathrm{d}f}{f^2}, \quad t \text{ large}$$

Hurst's empirical formula suggests that long-term natural phenomena give points clustering round $x = -\frac{1}{2}$, $y = -\frac{1}{2}$. Is it possible that there is an underlying law here, analogous to the relation between time-scale and release of energy in novæ and explosive variable stars?

Hurst's card experiment gives a function of exponentially decreasing autocorrelation and hence finite:

$$w(0) = 4\sigma^2\int_0^\infty r(t)\mathrm{d}t$$

an example of the 'ordinary' case. A line parallel to the line $\frac{R}{\sigma} = 1{\cdot}25\sqrt{N}$ in his figure gives a better fit to his observed points when $N > 200$ than his line $K = 0{\cdot}73$.

Acknowledgment is made to the Engineer-in-Chief, Marconi's Wireless Telegraph Co., Ltd., for permission to publish this communication.

D. S. PALMER

Marconi's Wireless Telegraph Co., Ltd.,
Great Baddow, Essex.
March 31.

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[2] Rice, S. O., *Bell System Tech. J.*, **23**, 282 (1944); **24**, 46 (1945).

Polymer-type Elasticity in Non-polymer Crystals

During the course of some current research[1] on the growth and breaking strains of various needle crystals, it appeared that the elastic moduli of α-hydroquinone had not yet been measured, so far as we could ascertain. While a determination of all the elastic constants proved impracticable, we have measured the Young's modulus along the *c*-axis of the crystal, both by a simple cantilever method and in direct tension.

Bending tests on six crystals gave a mean value for Young's modulus of $0{\cdot}430 \times 10^6$ lb./in.^{2} ($30{\cdot}2 \times 10^9$ kgm./cm.^{2}) with a coefficient of variation of 6·2 per cent. Two tensile tests gave a mean value of $0{\cdot}441 \times 10^6$ lb./in.^{2} ($31{\cdot}0 \times 10^9$ kgm./cm.^{2}). The crystals obeyed Hooke's law up to at least 0·1 per cent strain.

The value of E found for hydroquinone is quite exceptionally low for a crystalline material, being about a quarter of that for ice[2], which has itself one of the lowest published values. Of the relatively few results published for non-polymeric organic substances[3], hexamethylene tetramine is one of the lowest with Young's modulus in the <100> direction of $2{\cdot}03 \times 10^6$ lb./in.^{2} (143×10^9 kgm./cm.^{2}). The majority of inorganic salt crystals are considerably stiffer than this. Low stiffness in a continuous elastic solid, such as that of hydroquinone, is generally shown only by polymers, and in fact the modulus of hydroquinone is similar to that of many resins.

The low elastic moduli of polymers must be due, in the main, to the easy deformation of molecular networks and zig-zag chains which in the engineering sense are 'deficient structures', a state of affairs which presumably seldom occurs in non-polymer crystals. However, ten years ago, Powell[4] suggested a complicated lattice structure for the α-hydroquinone crystal which the engineer would certainly regard as deficient and which seems to admit of elastic deformations of the polymeric type. If Powell's proposed structure is substantially correct, it would account for the exceptionally low modulus which we have found, and conversely the elastic constant lends support to Powell's suggestion.

This communication is published by permission of the Chairman of Tube Investments, Ltd.

J. E. Gordon
A. T. K. Seville
D. M. Marsh

Tube Investments Research Laboratories,
Hinxton Hall, Cambridge. April 16.

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Polarization of Atmospherics

In a recent communication[1], Prof. S. R. Khastgir has illustrated a complex type of trace obtained with a twin-channel cathode-ray direction-finder when receiving atmospherics. He has claimed to have deduced from this record information regarding the polarization of the echoes received after various numbers of reflexions between the Earth and the ionosphere. I believe that the record which he gives as an example can be explained almost completely by the combination of a ground-wave and the echo received after only one ionospheric reflexion.

Fig. 1. Cathode-ray direction-finder trace

A sketch of the record is shown in Fig. 1. Ideally, a trace on a cathode-ray direction-finder is a straight line at an angle corresponding to the bearing of the flash[2], but Prof. Khastgir's Fig. 1*a* exhibits ellipticity and rotation of the bearing. The deflexions in the initial stages are linear, in a nearly horizontal direction, and then as time advances, the trace becomes elliptical with a clockwise rotation of the major axis, and the amplitude decreases.

The orientation of the trace is not stated, so it will be supposed arbitrarily that the horizontal and vertical deflexions represent the outputs of the east–west and north–south amplifiers respectively; in other words, that north is at the top of the diagram. The actual orientation of the loops is of minor importance, however, since they could be rotated into the north–south and east–west planes without changing the character of the record, except to rotate it through an equal angle. It is therefore valid to refer to equivalent north–south and east–west aerials whatever the true orientations. The amplitudes of successive cycles in the oscillatory outputs of the two amplifiers have been measured from the original photograph and can be represented by the solid curves in Fig. 2. The trace shown in Fig. 1 is asymmetrical, probably due to overloading of the output stages of one amplifier, so data have been taken only from the westerly part of the record. Thus the amplitudes have been plotted in Fig. 2 at $\frac{1}{4}$, $1\frac{1}{4}$, $2\frac{1}{4}$, etc., cycles of oscillation, and the east–west curve can then be extrapolated back to zero on the scale of cycles, which will be taken as time $t = 0$.

These curves are of the form to be expected if the instrument had narrow band-width and if a short impulse was applied to the east–west amplifier, followed by one applied to the north–south amplifier. The curves represent the subsequent ringing of the tuned circuits. No details of the frequency, band-width or number of tuned circuits were given, but the broken curves show the response (normalized in amplitude) of an amplifier with two tuned circuits

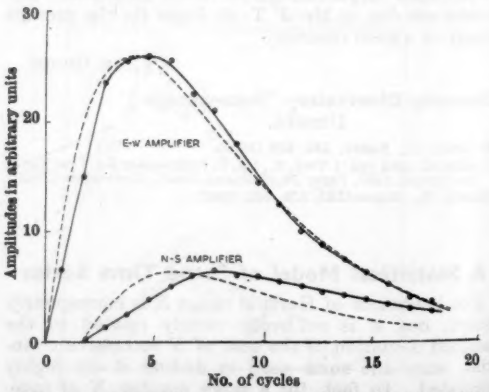

Fig. 2. Envelopes of voltages from cathode-ray direction-finder amplifiers: —⊙—, measured from cathode-ray direction-finder trace; – – –, theoretical envelope for amplifier with two tuned stages of equal selectivity

of equal selectivity, and an overall band-width of 580 c./s. This value was chosen to fit the east–west curve; a much smaller band-width would have been deduced if the north–south curve had been chosen for reference.

The general form of the cathode-ray direction-finder trace can be explained in terms of these curves. It is suggested that the east–west channel, the loop of which was almost in the plane of propagation, received the ground-wave, in the form of a short impulse, at time $t = 0$, and the north–south channel received the horizontally polarized component of the once-reflected ionospheric wave 1·7 cycles later. The corresponding vertically polarized ionospheric component would be expected to have some influence on the east–west channel but has been ignored. The source of the atmospheric was said to be 500 km. distant, corresponding to a delay time of 105 μsec. for a wave reflected once at the ionosphere at an effective height of 85 km. For this to be equivalent to 1·7 cycles, the frequency would have to be about 16 kc./s., which is reasonable for this type of work.

The first two oscillations of the east–west amplifier output are not accompanied by any north–south output and a straight-line trace is obtained. The north–south output is small for the next two oscillations, and the trace is still substantially linear, though deflected slightly in a clockwise direction. Thereafter the north–south output becomes gradually more important and leads to elliptical traces of decreasing eccentricity, and rotation of the major axis, while the amplitude decreases.

The form of the record has therefore been explained without reference to multiple echoes. Prof. Khastgir assumed that the relative phases of the amplifier outputs at a given time were those of equivalent continuous-wave fields at the input, and used this assumption to derive the polarization of the multiple ionospheric echoes. This procedure is incorrect, since the output voltages at any time depend mainly on the previous history of the atmospheric. Multiple echoes can only vary the oscillations of the tuned circuits induced by the initial impulses, and in the example shown their influence is apparently small. To deduce the polarization of the echoes from minor variations in the trace would require observations of a high order of accuracy.

Prof. Khastgir's trace could be produced, though not necessarily so, by a vertical discharge to ground, the horizontally polarized component of the ionospheric wave being introduced in the reflexion process. There is therefore no need to postulate a horizontal discharge channel.

This communication is published by permission of the Director of Radio Research of the Department of Scientific and Industrial Research.

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Slough, Bucks. Feb. 27.

[1] *Nature*, **181**, 404 (1958).
[2] Adcock, F., and Clarke, C., *J. Inst. Elect. Eng.*, **94**, Pt. III, 118 (1947).

Mr. F. Horner has considered the ringing of the tuned circuits of the two amplifiers connected to the 'crossed'-pair of loop-aerials of the cathode-ray tube direction-finder, when the atmospherics are received, and has attempted to explain our direction-finding records[1] which showed elliptical patterns of gradually decreasing eccentricity, tilt-angle and size along with one or more straight-line responses, as due to the combined effect of a ground-wave and the echo received after only one ionospheric reflexion.

In our direction-finder, each amplifier was tuned to 17 kc./sec. and had a band-width of about 300 c./sec. between half-power points. The planes of the 'crossed'-pair of loops were in the north-east and the south-east directions, and not in the east–west and the north–south directions as has been assumed by Horner. In the particular record illustrated in our communication, the direction of propagation of the atmospheric pulse was found to be 3° from the east measured in the clockwise direction. It is thus obvious that the amplitudes of the successive cycles in the oscillatory outputs of the two amplifiers cannot be represented by Fig. 2 of Horner's communication, which has been drawn from the horizontal and the vertical components of the displacements of our record.

We may take a very special case for the sake of simplicity to test Horner's view. Suppose that the direction of the radio-atmospheric is due east–west and the planes of the two 'crossed'-loop aerials are in the east–west and the north–south directions. If the source of the atmospheric is 500 km. distant, then the delay-time for a wave reflected once at the ionosphere at an effective height of 85 km. is 105 μsec. Only the ground-wave is received by the east–west loop, and the horizontally polarized component of the ionospheric wave is received by the north–south loop. The influence of the corresponding vertically polarized component on the east–west loop has been ignored. Suppose also that the amplitude of the once-reflected ionospheric wave is half that of the direct wave and that the amplitude of the horizontally polarized component is one-fifth that of the vertically polarized component. Taking now the amplitude distribution for the successive cycles from an oscillogram taken by Mr. R. S. Srivastava (unpublished work) in this Laboratory, on 12 kc./sec., we can estimate the distribution of amplitude of the horizontally polarized component of the once-reflected ionospheric wave for the successive cycles. Since in our case the delay-time is 105 μsec., the response of the horizontally polarized component of the once-reflected ionospheric wave will start at about 1·3 cycles. We can thus find the ratio of the amplitude of the ground-wave to the amplitude of the horizontally polarized component, corresponding to the ratio of the outputs of the east–west and the north–south loops for 2·3, 3·3, 4·3, . . . cycles, respectively. This ratio, as obtained from Srivastava's oscillogram, is found to be practically constant after the second oscillation. Since the phase-difference between the ground-wave and the once reflected ionospheric wave is $1·3 \times 360°$, the combined effect will give a narrow ellipse with a small angle of tilt. To obtain an extra check on the conclusion drawn here, Bowe's oscillogram for 10 kc./sec. has also been examined on similar lines. The results are shown in Table 1.

The angle of tilt has been measured from the east in the clockwise direction. The results given in Table 1 show that for 10 and 12 kc./sec., the ringing of the tuned amplifiers has to some extent an effect in producing an elliptical response of small eccentricity

Table 1

Experimenters	Frequency (kc./sec.)	Average ratio of the amplitudes after second oscillation for eight successive cycles	Computed angle of tilt after second oscillation
Srivastava	12	9·95 ± 0·05	1° 45′
Bowe	10	9·3 ± 0·1	7° 20′

and angle of tilt. A complete explanation of the pattern observed by us does not seem to be possible according to Horner's view. It is to be noted, however, that in obtaining the direction-finding pattern, where the angle of tilt was found to vary from 6° to 23°, the amplifiers were tuned to a different frequency, namely, 17 kc./sec.

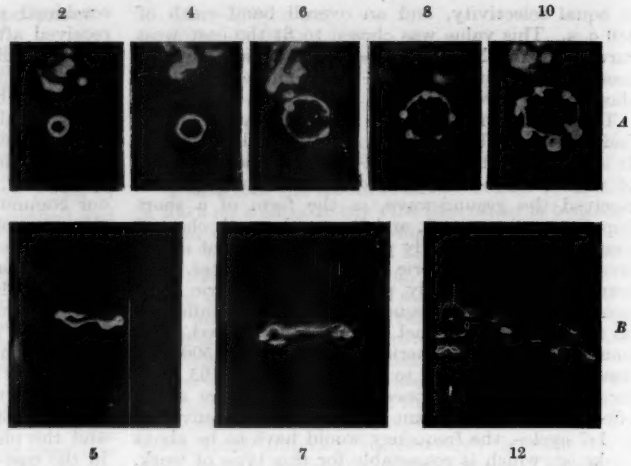
We would also like to direct attention to the following observations: (i) Calculations from the observed elliptical patterns, illustrated in our communication, have shown that the phase-difference between the voltages induced in the two 'crossed' loop-aerials varied from 2° to 32° from the second to the ninth ellipse. This cannot be explained according to Horner's view, as the ringing of the tuned circuits cannot introduce such varying phase-difference between the voltages induced in the two 'crossed' loop-aerials. (ii) In numerous oscillograms, the number of observed ellipses was found to be nearly the same as the number of ionospheric reflexions. (iii) The first few ionospheric echoes in a number of oscillograms were of appreciable amplitude. Their influence cannot therefore be ignored. (iv) The straight lines observed along with the ellipses were bunched within a small angle. According to Horner's explanation, the first two oscillations of one amplifier due to the ground-wave alone would give a straight line. This would give one and only one straight line in the direction of propagation. The observed straight-line traces slightly inclined to one another before the arrival of the first echo cannot therefore be explained on this view.

It is true that, in deriving the polarization of the multiple ionospheric echoes, we did not take into account the ringing of the tuned circuits in the two amplifiers. Horner, on the other hand, considered the ringing of the tuned circuits, but ignored altogether the polarization of the ionospheric echoes. There is no doubt that the polarization and the ringing of the tuned circuits in the two amplifiers should be considered in interpreting the complex patterns.

S. R. Khastgir

Wireless Laboratory,
Physics Department,
Banaras Hindu University.

[1] Khastgir, S. R., *Nature*, **181**, 404 (1958).
[2] Bowe, P. W. A., *Phil. Mag.*, **42**, 121 (1951).



Figs. 1*A* and *B*. Numbers denote time in seconds after the drop enters the tank

Instability Effects in Vortex Rings produced with Liquids

One of the commonest examples of a vortex phenomenon may be observed in the formation of smoke rings. Detailed studies of the structure of smoke rings were made many years ago by R. W. Wood[1]. Smoke is, however, rather unsatisfactory for observation because of rapid diffusion and the fact that the rings are easily disturbed by air currents.

It was discovered that the changes in the physical evolution of a vortex with time could be more easily observed and photographed in a liquid. Once the vortex process is started no additional energy is required to keep the ring in motion. The changes in the shape of the vortex are governed by its rotational energy and the frictional or viscous forces in the liquid medium. As these liquid vortex rings aged, definite progressive instability effects were observed. The changing structure of the vortex as instability occurred made them interesting subjects for study.

A clay–water mixture was used to produce visible rings. Both kaolinite and bentonite-type clays were found to be satisfactory; however, kaolinite produced rings which maintained their continuity for a longer period of time and was selected for study. A 5 per cent mixture was used, and most of the clay particles stayed in suspension for several hours. The suspension was placed in a micropipette which was placed vertically over a cylindrical glass tank 6 in. in diameter and 14 in. deep, filled with water. The tip of the pipette was located about 2 cm. above the water and was adjusted to deliver about 0·1 c.c. per drop. Under these conditions a vortex ring formed less than one second after a drop of the clay–water mixture was ejected and entered the tank.

The various stages of evolution of a number of rings, as viewed from above the tank, are shown in Fig. 1*A*. The numbers represent the approximate time elapsed in seconds after the drops entered the tank. The rings are seen to increase rapidly in diameter. From the theorems of Helmholtz[2] it is stated

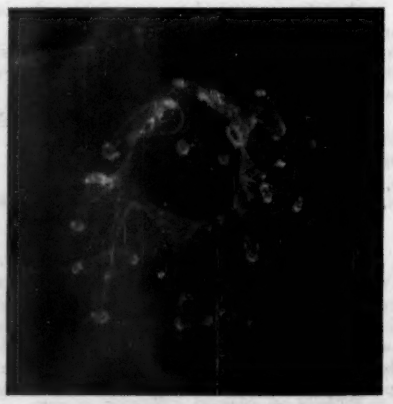


Fig. 2

Fig. 3

that, as the vortex stretches, the angular velocity of rotation increases in proportion to the decrease in cross-sectional area. This relationship is given by Prandtl[3] as :

$$\Gamma = 2\,\omega\,a$$

where Γ is the circulation of the vortex filament, ω its angular velocity, and a the cross-section. With the increase in angular velocity of the vortex, instability occurs, and thick and thin regions begin to form around the ring as may be seen in the 4-sec. photograph. After about six seconds the beginning of secondary rings may be seen, and these are well formed after eight seconds. These secondary rings also expand and become unstable, as may be seen in the last photograph of this series.

Since secondary rings have a greater angular velocity than the primary vortex, they travel downward into the tank at a faster rate. This effect may be seen in Fig. 1*B*, showing photographs taken normal to the direction of travel of the rings or viewed from the side of the glass tank. The thick regions which form secondary rings are on a lower plane than the primary ring. At twelve seconds, portions of the second set of rings are distorted and descend more rapidly.

The formation of the third set of rings may be seen in detail in Fig. 2, taken after about seventeen seconds and again viewed from above the tank. The third ring groups are formed at the tips of triangular streamers which a few seconds before were the second set of rings. Five complete sets of rings have been observed ; however, these are difficult to photograph because of the lack of contrast and diffusion of the suspension.

Occasionally the forces on the clay–water drop were not uniform as it entered the tank and irregularly shaped secondary rings were formed as shown in Fig. 3. Here most of the primary ring has flowed into one large secondary ring formation.

W. C. Levengood

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March 3.

[1] Wood, R. W., *Nature*, **63**, 418 (1901).
[2] von Helmholtz, *Crelles J.*, **55**, 25 (1858).
[3] Prandtl, L., "Essentials of Fluid Dynamics", pp. 56–74 (Hafner Pub. Co., New York, 1952).

Corrosion of Ten Metals in Boiling Hydrochloric Acid when in Contact with Rhodium, Palladium, Iridium and Platinum

The corrosion of a metal in acid solution involves essentially the transfer to another species of one or more electrons by the metal atom, followed by solvation in the aqueous solution. In order to obtain a better understanding of the electron transfer process in this reaction, the rates of corrosion of aluminium, cadmium, cobalt, iron, lead, manganese, nickel, tin, titanium, and zinc were studied in boiling 2 *M* hydrochloric acid, with and without contact with platinum, iridium, rhodium and palladium.

The metals subjected to corrosion were machined in the shape of a cylinder with a threaded hole in one end, and the platinum metals were machined as a cylinder with a threaded shaft. When assembled, the resulting cylinder had a surface area of approximately 3·8 cm.^{2}, with equal areas of the corroding metal and platinum metal exposed. Prior to an experiment, the separate cylinders were etched in hydrochloric acid so that a similar surface to that formed during the corrosion experiment would be present at the start. The major results can be summarized as follows.

(1) With the exception of titanium, the rates of corrosion were increased when coupled to the platinum metals. Titanium was unique among the metals studied in that the rate of corrosion was decreased to a very low value when it was coupled to any of the four platinum metals. Iron was unusual in that its corrosion-rate was increased only 1·25–1·42 times, whereas the other metals exhibited much larger increases.

(2) The relative effectiveness of the platinum metals in increasing the corrosion varied with the metal undergoing corrosion. For example, iridium was the most effective in three cases and least effective in four cases. Palladium was the most effective in one case and the least effective in five cases. The relative effectiveness of the platinum metals was very similar for metals occupying similar positions in the periodic table. This similarity in behaviour was exhibited particularly for tin and lead and for nickel and cobalt. It is felt that the explanation for these results will be found in the specific electronic interaction between the two members of the couple rather than in the lowering of the hydrogen overvoltage by the platinum metal. If the platinum metals increase the corrosion-rate solely by virtue of reducing the hydrogen overvoltage, as many corrosion workers have assumed, it would be expected under the conditions used that the relative effectiveness of the platinum metals would remain the same regardless of the metal to which they were coupled.

(3) The discrimination between the platinum metals was least for those farther away from platinum in the e.m.f. series and greatest for the more noble metals. For example, the most active metal, platinum, increased the rate of corrosion of aluminium 13-fold, while the least active metal, palladium, increased the rate 10·5-fold. The discrimination ratio here is 13/10·5 or 1·24. In the case of lead, iridium increased the rate 586-fold and palladium 15·5-fold, yielding a discrimination ratio of 38.

(4) For eight of the ten metals studied, the average rate of corrosion when coupled to the four platinum metals was related to the standard electrode potential. A moderately good fit of the data for tin, lead, cobalt,

nickel, cadmium, iron, zinc and manganese was obtained with a log–log plot. The data for aluminium and titanium were greatly out of line, aluminium by two orders of magnitude and titanium by many orders of magnitude.

These experiments are being extended to include the corrosion of other metals and alloys and to include the effect on the corroding metals of contact with ruthenium, osmium, silver and gold.

This research was supported by the American Can Company. We are indebted to the International Nickel Company for lending us the platinum and the palladium and to Baker and Company for lending us the rhodium and iridium.

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March 14.

Estimation of Hydrogen Peroxide in Culture Media

The small quantities of hydrogen peroxide produced in culture media and also by some antituberculous substances are thought to have an inhibitory effect on catalase-negative strains of *Mycobacterium tuberculosis* resistant to isoniazid[1,2]. In studying this problem an indirect polarographic method has proved a sensitive and accurate way of estimating peroxide. Although direct polarographic estimation of hydrogen peroxide is possible in some simple media, the decomposition current of more complex media may obscure the hydrogen peroxide wave.

The indirect method depends on the measurement of oxygen released from hydrogen peroxide by the action of catalase. 10-ml. samples of media to be tested are freed of oxygen by the passage of nitrogen. Six units of Worthington catalase are added, and the oxygen-diffusion current measured[3] at −0·50 V. with a recording polarograph, using a mercury dropping electrode and a saturated calomel half-cell and agar bridge. A standard curve of oxygen-diffusion current against peroxide concentration is constructed for each batch of media. The unknown concentration of peroxide is found by entering the oxygen-diffusion current in the standard curve. When only occasional observations are required Hohn's method[4] of standard addition can be used.

With the media so far used we have found a linear relation between diffusion current and concentration of hydrogen peroxide over a wide range. For example, the regression coefficient (b) in the regression equation:

$$\log(\text{oxygen diffusion current}) = b \log(\text{concentration of hydrogen peroxide}) + a$$

for Kirchner[5] medium, was 1·0069 (standard error 0·0125, $N = 7$) over the range 0·03–30 μgm./ml. of hydrogen peroxide. The lower limit of sensitivity (0·03 μgm./ml.) was determined by the ultimate sensitivity of the instrument. The Kirchner medium, which contains 10 per cent horse serum, was at pH 7·5 at 22° C. The diffusion current of oxygen was 19 mμamp. for a concentration of 0·1 μgm./ml. of hydrogen peroxide. The instrument was a Tinsley type 13 polarograph, and the capillary constant ($m^{2/3}t^{1/6}$) was 2·28.

It cannot be stated that specificity of method has been proved, because peroxides other than hydrogen peroxide may be broken down by catalase to produce oxygen. However, there appears to be no evidence that other peroxides occur in significant concentration. The other peroxides which have been shown to be substrates for catalase, such as methyl hydrogen peroxide[6], are broken down very slowly compared with hydrogen peroxide.

We believe this method should be applicable in biological systems which contain neither catalase nor an inhibitor of this enzyme.

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Department of Bacteriology,
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London, S.E.1.
April 18.

[1] Middlebrook, G., *Amer. Rev. Tuberc.*, **69**, 472 (1954).
[2] Knox, R., *J. Gen. Microbiol.*, **12**, 191 (1955).
[3] Kolthoff, I. M., and Lingane, J. J., "Polarography" (Interscience Pub., Inc., New York, 1941).
[4] Hohn, H., "Chemische Analysen mit dem Polarographen", 51 (Berlin, 1937).
[5] Mackie, T. J., and McCartney, J. E., "Handbook of Practical Bacteriology", 9th edit. (E. and S. Livingstone, Ltd., Edinburgh, 1953).
[6] Chance, B., *J. Biol. Chem.*, **179**, 1341 (1949).

Anomalous Behaviour of β-Diketone Complexes of the Lanthanons in Organic Solvents

The acetylacetonates of rare earths are known[1] to possess dimeric formulæ R_2Ac_6 (where R denotes the rare earth elements and Ac acetylacetone) as determined from the rise of boiling points of their solutions in nonpolar organic solvents such as benzene, carbon disulphide, carbon tetrachloride, etc. We have found, however, that in acetone, acetylacetonates and benzoylacetonates of lanthanum and yttrium (the two salts studied) are monomeric, RAc_3.

We find that the above complexes behave abnormally in dioxane. In this solvent, they produce lowering of boiling point instead of elevation. The cause of this anomalous behaviour is not clear. The equation[2] giving the elevation of boiling point produced by an appreciably volatile solute is $\Delta T_e' = K_e m\ 1 - k$), where $\Delta T_e'$ is the observed elevation of boiling point and k is the ratio of the mole fraction of solute in the vapour phase to that in the liquid phase. If k is greater than unity, that is, if the concentration of the solute in the vapour phase is greater than that in the solution, a negative elevation (depression) of boiling point may occur. But in this case, the analysis of the vapour phase indicated that these substances are only slightly volatile with the vapour of the solvent. The acetylacetonates of other trivalent metals such as aluminium, iron and chromium are more volatile, but these latter complexes behave normally in all the solvents studied, being always monomeric and producing an elevation of boiling point.

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Inorganic Chemistry Laboratory,
Calcutta.
April 7.

[1] Biltz, W., *Annalen*, **331**, 334 (1904).
[2] Glasstone, S., "Text Book of Physical Chemistry", 650, 2nd edit. (Macmillan, London, 1946).

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, June 16

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Gore, London, S.W.7), at 3 p.m.—Annual General Meeting.

BRITISH COMPUTER SOCIETY (at the Northampton College of Advanced Technology, St. John Street, London, E.C.1), at 5.30 p.m. —First Annual General Meeting. 6.30 p.m.—Dr. M. V. Wilkes, F.R.S.: "The Second Decade of Computer Development" (Presidential Address).

BRITISH SOCIETY FOR THE HISTORY OF SCIENCE, PHILOSOPHY OF SCIENCE GROUP (in the Joint Staff Common Room, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. Imre Lakatos: "On the Methodology of Mathematics".

UNIVERSITY OF LONDON (in the Anatomy Lecture Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. Marshall Clagett (Wisconsin): "Before Galileo: the Science of Mechanics in the Middle Ages".*

Wednesday, June 18

ROYAL METEOROLOGICAL SOCIETY (at 49 Cromwell Road, London, S.W.7), at 5 p.m.—Scientific Papers.

SOCIETY FOR ANALYTICAL CHEMISTRY, MICROCHEMISTRY GROUP (in the Restaurant Room of "The Feathers", Tudor Street, London, E.C.4), at 6.30 p.m.—Discussion on "The Determination of Elements other than C,H,O,N,S and Cl,Br,I in Organic Compounds", opened by Dr. A. MacDonald and Dr. R. Belcher.

WOMEN'S ENGINEERING SOCIETY, LONDON BRANCH (at the Central Electricity Authority Headquarters, Winsley Street, London, W.1), at 6.45 p.m.—Annual General Meeting.

Wednesday, June 18—Saturday, June 28

CHEMICAL AND PETROLEUM ENGINEERING EXHIBITION (at Olympia, London, W.14).*

Thursday, June 19

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Prof. David Keilin, F.R.S.: "The Problem of Anabiosis or Latent Life History and Current Concepts" (The Leeuwenhoek Lecture).

CIBA FOUNDATION FOR THE PROMOTION OF INTERNATIONAL CO-OPERATION IN MEDICAL AND CHEMICAL RESEARCH (at the Royal Institution, 21 Albemarle Street, London, W.1), at 5 p.m.—Prof. Dr. F. Bourliere (Faculté de Médecine de Paris): "The Comparative Study of Age Changes".

LONDON MATHEMATICAL SOCIETY (at the Royal Astronomical Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Prof. C. B. Allendoerfer: "Topological Applications of Singular Differential Forms".

ROYAL SOCIETY OF TROPICAL MEDICINE AND HYGIENE (at Manson House, 26 Portland Place, London, W.1), at 7.30 p.m.—51st Annual General Meeting, followed by Prof. A. W. Woodruff, F.R.C.P.: "Medicine in China To-day".

Friday, June 20

BRITISH INSTITUTE OF RADIOLOGY, incorporated with the RÖNTGEN SOCIETY (in the Reid-Knox Hall, 32 Welbeck Street, London, W.1), at 2 p.m.—Radiobiology Meeting.

INSTITUTE OF NAVIGATION (at the Royal Geographical Society, 1 Kensington Gore, London, S.W.7), at 5.15 p.m.—Discussion on "The Significance of Blunders in Navigation".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT LECTURER or LECTURER IN PURE MATHEMATICS—The Registrar, University College, Singleton Park, Swansea (June 21).

ASSISTANT LECTURER (suitably qualified graduate) IN BOTANY in the Department of Biological Sciences—The Registrar, Wye College (University of London), near Ashford, Kent (June 21).

DEMONSTRATOR IN PHARMACEUTICS—The Registrar, The University, Nottingham (June 21).

DEMONSTRATOR (suitably qualified graduate) IN ZOOLOGY (AGRICULTURAL ENTOMOLOGY) in the Department of Biological Sciences—The Registrar, Wye College (University of London), near Ashford, Kent (June 21).

RESEARCH ASSISTANT IN PHYSIOLOGY—The Registrar, The University, Sheffield (June 21).

SENIOR LECTURER (honours graduate in pharmacy or with other suitable qualifications) IN PHARMACOLOGY—The Registrar, The Technical College, Sunderland, Co. Durham (June 21).

SENIOR LECTURER (with a degree in statistics or in mathematics with research experience in statistics) IN MATHEMATICAL STATISTICS—The Clerk to the Governors, Chelsea College of Science and Technology, Manresa Road, London, S.W.3 (June 21).

RESEARCH SCHOLAR IN ENTOMOLOGY—The Registrar, University College of the West Indies, Kingston 7, Jamaica (June 22).

LECTURER (with a recognised degree in agriculture) IN AGRICULTURE—The Clerk to the Governors, Essex Institute of Agriculture, Writtle, Chelmsford, Essex (June 25).

UNIVERSITY LECTURERS or UNIVERSITY ASSISTANT LECTURERS IN MATHEMATICS—The Secretary of the Appointments Committee of the Faculty of Mathematics, Bene't Street, Cambridge (June 25).

RESEARCH ASSISTANTS IN THE CERAMICS DIVISION, Houldsworth School of Applied Science, to undertake mainly physical and physico-chemical investigations of the diffusion of gases in dense ceramics and in glass—The Registrar, The University, Leeds 2 (June 26).

ASSISTANT LECTURER IN THE DEPARTMENT OF BOTANY—The Registrar, The University, Leicester (June 27).

SCIENTIFIC OFFICER (with an honours degree in chemistry and a good knowledge of carbohydrates, and preferably some research experience) IN THE TECHNICAL CHEMISTRY DEPARTMENT, for studies in the composition of grass and silage—The Secretary, Hannah Dairy Research Institute, Ayr, Scotland (June 27).

KEEPER (with a good honours degree in botany, a knowledge of economic botany, and the ability to present the subject to the public) OF THE DEPARTMENT OF BOTANY; and an ASSISTANT (TECHNICAL) (with an appropriate university degree or equivalent qualification) IN THE DEPARTMENT OF VERTEBRATE ZOOLOGY, to assist primarily in taxonomic and laboratory work—The Director, Liverpool Public Museums, Carnatic Hall, Elmswood Road, Liverpool 18 (June 28).

LECTURER/ASSISTANT LECTURER IN PHYSICS—The Registrar, The University, Hull (June 28).

POST-DOCTORAL FELLOW IN CHEMISTRY, for research with Prof. R. D. Haworth, F.R.S., on the chemistry of naturally occurring tannins—The Registrar, The University, Sheffield (June 28).

LECTURER or ASSISTANT LECTURER IN THE DEPARTMENT OF PHYSICS—The Registrar, The University, Leeds 2 (June 30).

LEVERHULME STUDENT (with a postgraduate diploma in chemical engineering or equivalent) IN CHEMICAL ENGINEERING—The Registrar, King's College, Strand, London, W.C.2 (June 30).

SCIENTIFIC OFFICER (with a good honours degree in an appropriate subject), to study aspects of the mechanisms of transmission of insect-borne plant viruses; and a PRINCIPAL SCIENTIFIC OFFICER (with a good honours degree in an appropriate subject), to lead the genetical investigations arising from the Institute's rubus, ribes and vegetable breeding programmes—The Secretary, Scottish Horticultural Research Institute, Mylnefield, Invergowrie, by Dundee (June 30).

SENIOR RESEARCH ASSISTANT (honours graduate in engineering or physics) IN THE DEPARTMENT OF MECHANICAL ENGINEERING—The Registrar, The University, Nottingham (June 30).

TUTORIAL RESEARCH STUDENT IN BOTANY; and a TUTORIAL RESEARCH STUDENT IN ZOOLOGY—The Principal, Royal Holloway College (University of London), Englefield Green, Surrey (June 30).

RESEARCH ASSISTANTS, for experimental work on the thermodynamic properties of mixtures—The Registrar, The University, Reading (July 1).

CHAIR OF LIGHT ELECTRICAL ENGINEERING in the Imperial College of Science and Technology—The Academic Registrar, University of London, Senate House, London, W.C.1 (July 8).

SENIOR LECTURER IN THE DEPARTMENT OF AGRICULTURAL BOTANY—The Registrar, University College of Wales, Aberystwyth (July 12).

LECTURER (with special qualifications in physical chemistry) IN THE DEPARTMENT OF CHEMISTRY AND CHEMICAL ENGINEERING, University of the Witwatersrand, Johannesburg, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, July 25).

RESEARCH FELLOWS (Grade I or Grade II) IN (*a*) CHEMISTRY, to undertake fundamental investigations on the chemistry of West African medicinal plants; and (*b*) ZOOLOGY, for research into the ecology of grain-eating weaver birds in Northern Nigeria, at University College, Ibadan, Nigeria—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (July 30).

LECTURER or ASSISTANT LECTURER IN CHEMISTRY at the University of Malaya—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (July 31).

SENIOR LECTURER or LECTURER IN GEOLOGY at the University of Auckland, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, July 31).

CHAIR OF BOTANY in the University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Hong Kong, August 15).

LECTURER IN GEOLOGY—The Secretary, University College, Cork, Ireland (September 30).

ASSISTANT PHYSICIST (with a first- or second-class honours degree and preferably with previous experience) IN THE RADIOTHERAPY CENTRE—The Secretary, St. Luke's Hospital, Guildford, Surrey.

CHEMIST/PETROLOGIST (with an honours degree in geology and at least three years postgraduate experience as a chemist and/or petrologist) IN THE GEOLOGICAL SURVEY DEPARTMENT, Government of British Guiana—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.105/30/08/T.

EXPERIMENTAL/ASSISTANT EXPERIMENTAL OFFICER (with H.S.C. (Science) or equivalent qualification), to assist in research into the physical and mechanical properties of high explosives—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berkshire, quoting Ref. C/1480/34.

LECTURER (fully qualified electrical engineer, preferably with experience or special interest in one or more of the following branches: electrical measurement, high-voltage technique, utilization of electric power, or electrical plant) IN THE DEPARTMENT OF ELECTRICAL ENGINEERING—The Registrar, Loughborough College of Technology, Loughborough, quoting Ref. 22/G.

PHYSICS RADIOGRAPHER/LABORATORY ASSISTANT, to work with physics staff in radiotherapy, X-ray field planning, and operation of protections service—The Personnel Officer, St. Thomas' Hospital, London, S.E.1.

RESEARCH ASSISTANT (Ph.D.), to participate in researches on organo-metallic and carbonyl compounds—Prof. G. Wilkinson, Inorganic Chemistry Laboratory, Imperial College, London, S.W.7.

RESEARCH ASSISTANT (with some postgraduate experience, preferably in biochemistry and general analysis)—The Secretary, St. George's Hospital Medical School, London, S.W.1.

SENIOR LABORATORY STEWARD (with suitable qualification and experience in laboratory work)—The Headmaster, Beckenham and Penge Grammar School for Boys, High Street, Penge, London, S.E.20.

SENIOR LECTURER IN ELECTRICAL POWER; a LECTURER IN ELECTRICAL CIRCUITS AND MEASUREMENTS; and an ASSISTANT LECTURER IN ELECTRICAL ENGINEERING—The Secretary, Northampton College of Advanced Technology, St. John Street, London, E.C.1.

SENIOR LECTURER or LECTURER (graduate in pharmacy, with adequate experience in teaching, research, hospital or industry), IN PHARMACEUTICS—The Registrar, College of Technology, Ashley Down, Bristol 7.

SENIOR LECTURER (with graduate qualifications and experience with digital computers), mainly for new courses for the training of supervisor maintenance engineers on digital computers—The Principal, Technical College, Hempstead Road, Watford, Herts.

SENIOR RESEARCH OFFICER (PLANT PATHOLOGY) (with a good honours degree in botany (plant pathology) and suitable professional and administrative experience) IN THE PLANT PATHOLOGY DIVISION, Department of Agriculture, Kenya, to take charge, and to guide and direct work of other pathologists in the Division—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/7/015.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

The British Journal Photographic Almanac, 1958. Edited by Arthur J. Dalladay. Pp. 616+32 plates. (London: Henry Greenwood and Co., Ltd., 1958.) 8s. 6d. net. [283

Department of Scientific and Industrial Research. The Investigation of Atmospheric Pollution: a Report on Observations in the year ended 31st March, 1956. (Twenty-Ninth Report.) Pp. iv+124. (London: H.M. Stationery Office, 1958.) 7s. net. [283

Colonial Office. Colonial Research Studies No. 25: The Exploitation of Sea Birds in Seychelles. By The Hon. M. W. Ridley and Lord Richard Percy. Pp. viii+78+33 plates. (London: H.M. Stationery Office, 1958.) 12s. 6d. net. [283

University of London. University College Annual Report, 1956–1957. Pp. 89. (London: University College, 1958.) [283

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General Register Office. The Registrar General's Quarterly Return for England and Wales—Births, Deaths and Marriages; Infectious Diseases; Weather; Population Estimates, Quarter ended 31st December, 1957. (No. 436, 4th Qtr. 1957.) Pp. 28. (London: H.M. Stationery Office, 1958.) 2s. net. [283

The Registrar General's Decennial Supplement, England and Wales, 1951. Area Mortality. Pp. xxvii+82. (London: H.M. Stationery Office, 1958.) 70s. net. [283

Ministry of Housing and Local Government. First Report of the Trade Effluents Sub-Committee of the Central Advisory Water Committee. Pp. 10. (London: H.M. Stationery Office, 1958.) 9d. net. [283

Regional Advisory Council for Higher Technological Education: London and Home Counties. Printing Education in London and the Home Counties. Pp. 18. (London: Regional Advisory Council for Higher Technological Education: London and Home Counties, 1957.) 1s. 6d. [313

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Aero Research Technical Notes. Bulletin No. 183 (March, 1958): Ultra-Light Aircraft: Machine made with 'Aerolite 300' and 'Aerodux 185' Adhesives. Pp. 6. (Duxford: Aero Research Limited, 1958.) [313

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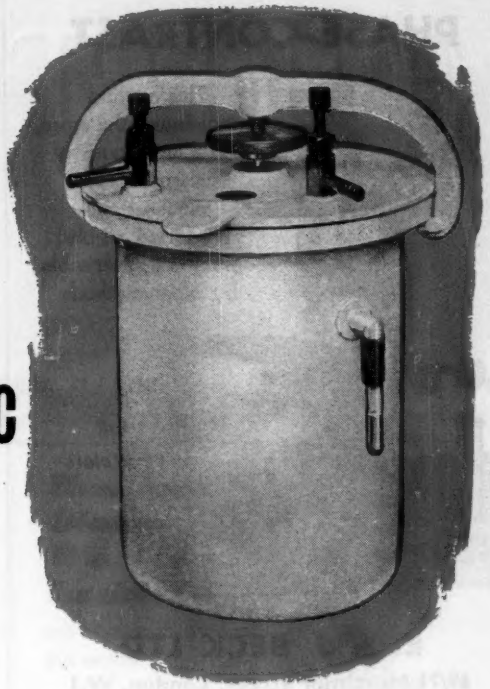

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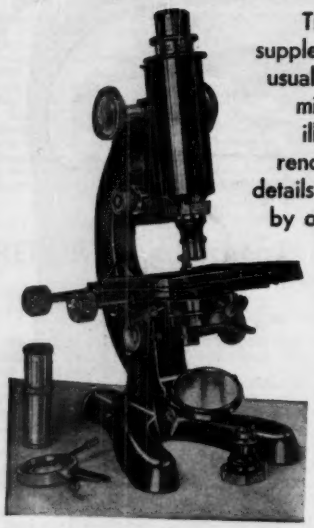

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